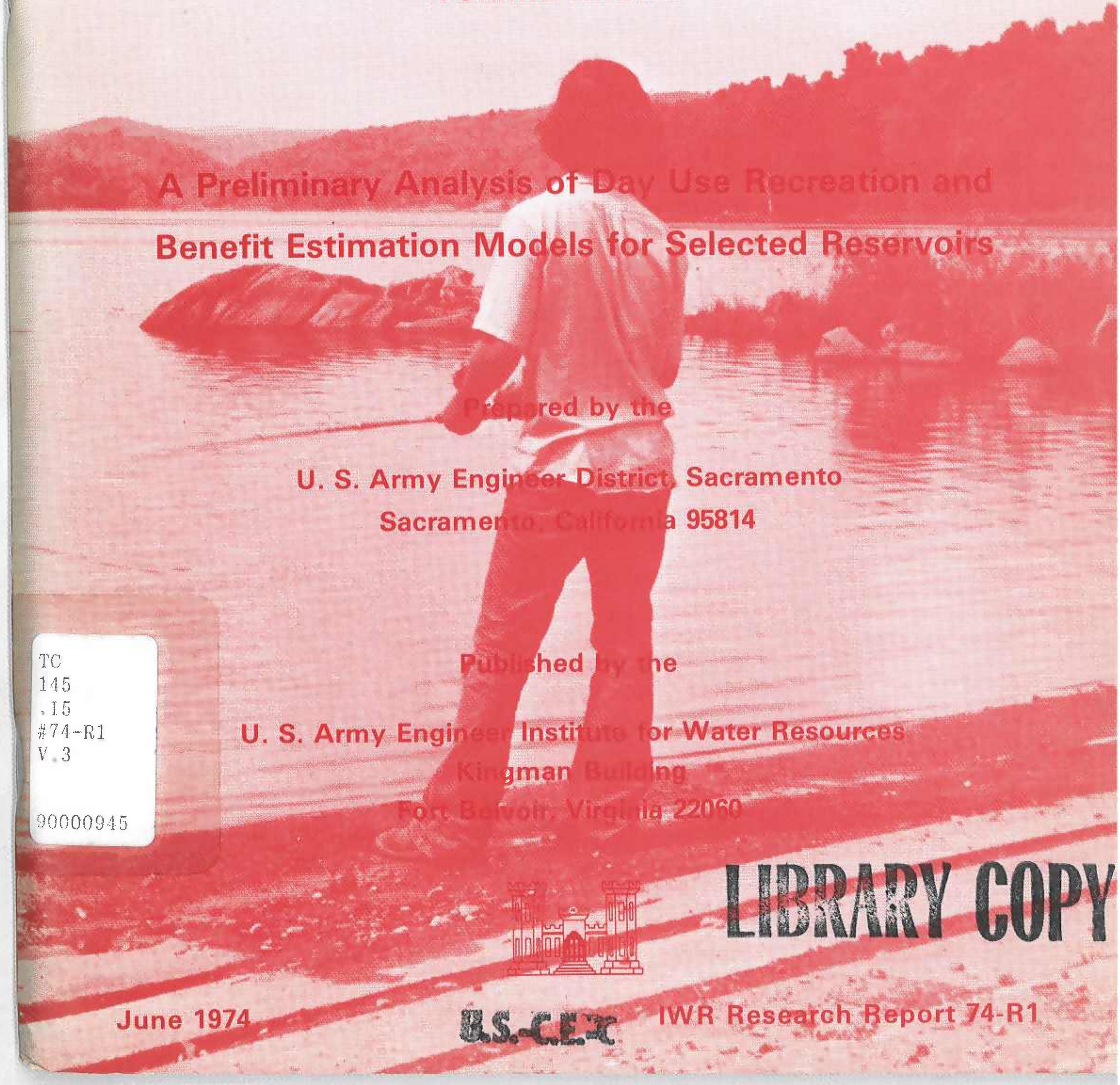
PLAN FORMULATION AND EVALUATION STUDIES — RECREATION

Volume III of V



A Preliminary Analysis of Day Use Recreation and Benefit Estimation Models for Selected Reservoirs

Prepared by the

U. S. Army Engineer District, Sacramento
Sacramento, California 95814

Published by the

U. S. Army Engineer Institute for Water Resources
Kingman Building
Fort Belvoir, Virginia 22060

June 1974

U.S.C.E.

IWR Research Report 74-R1

PLAN FORMULATION AND EVALUATION STUDIES - RECREATION

Volume III of V

A Preliminary Analysis of Day Use Recreation and Benefit Estimation Models for Selected Reservoirs

A Report Submitted to the
Department of the Army
Office of the Chief of Engineers

Published by the
U. S. Army Engineer Institute for Water Resources
Kingman Building
Fort Belvoir, Virginia 22060

Prepared by

Richard E. Brown
William J. Hansen

U. S. Army Engineer District, Sacramento
Sacramento, California 95814

Copies may be purchased from:

National Technical Information Service
U. S. Department of Commerce
Springfield, Virginia 22151

June 1974

IWR Research Report 74-R1

This report was originally submitted to the Department of the Army, Office of the Chief of Engineers by the U. S. Army Engineer District, Sacramento. Its contents are not to be construed as necessarily representing the views of the federal government or of the U. S. Army Corps of Engineers.

PREFACE

In 1962, the Chief of Engineers initiated Corps-wide sampling of the existing recreation use on Corps of Engineers civil works reservoir projects. The data collected were incorporated into existing planning processes, provided the basis for improved administration of operating projects, and provided the foundation for specialized studies. An evaluation of the data collected indicated that improvements could be made to make the data more useful. Consequently, in 1965 the Director of Civil Works authorized studies to be undertaken to:

a. Evaluate the recreation use data collection procedure and recommend methods for improving the statistical accuracy of such data and applying standardized data collection on a Corps-wide basis.

b. Develop methodology for recreation use prediction. Preliminary methodology to be developed as soon as possible and a long-range research program initiated to improve and refine the methodology.

c. Develop methodology for determination of the number and type of recreation facilities needed to serve a given number of recreation days of use (facility load criteria).

d. Develop methodology for determination of recreation benefits.

The studies have been performed under the general functional direction of Mr. Harold L. Blakey, Office, Chief of Engineers, with the actual work assigned and performed in the Sacramento District, formerly under the direct supervision of Mr. Dale Crane and presently under the direct supervision of Mr. Fred Kindel. This report is the fourth of a series to be published indicating significant results obtained from these studies. The first was Contract Report No. 1, entitled "Analysis of Recreational Use of Selected Reservoirs in California." The second was Technical Report No. 1, entitled "Evaluation of Recreation Use Survey Procedures." The third was Technical Report No. 2, entitled "Estimating Initial Reservoir Recreation Use."

This report presents results of a portion of the studies authorized by the Director of Civil Works and demonstrates a methodology for developing day use recreation visitation and benefit estimation models. Staff research efforts were performed by Mr. Richard E. Brown and Mr. William J. Hansen, under the research project leadership of Mr. Fred Kindel. Dr. Jack L. Knetsch, Director of the Natural Resources Policy Center, the George Washington University, and Dr. Leonard Merewitz, School of Business Administration, University of California, Berkeley, provided expert consultant services and invaluable assistance throughout the entire study. Special appreciation is extended to the office and field personnel in the Fort Worth and Sacramento Districts who collected the data which provide the basis for this report.

TABLE OF CONTENTS

	Page
PREFACE	iii
SUMMARY	vii
PART I: INTRODUCTION	
General	1
Purpose and Scope	3
PART II: DATA DESCRIPTION	
The Sites	4
Use Variable	10
Areal Observation Units	13
Variables Influencing Use	15
PART III: DAY USE RECREATION ESTIMATORS	
The Estimator	21
Recreation Day Use Estimator - Fort Worth Region	25
Recreation Day Use Estimator - Sacramento Region	27
A Comparison of the Regional Estimators	28
PART IV: DEMAND AND BENEFIT ESTIMATION	
Willingness to Pay	32
Variable Travel Costs - A Proxy for Price	34
An Adjustment for the Disutility of Time	36
Benefit Computations for the Study Reservoirs	40
PART V: CONCLUSIONS	42
REFERENCES	43
APPENDICES	
Appendix A - County Sets for Fort Worth Region	
Appendix B - County Sets for Sacramento Region	
Appendix C - An example of Benefit Calculations	

TABLE OF CONTENTS (Cont'd)

Page

LIST OF TABLES AND FIGURES

List of Tables

Table 1. Summary of Reservoir Data - Fort Worth District 7
Table 2. Summary of Reservoir Data - Sacramento District 9
Table 3. Survey Estimates of Day Use Recreation 12
Table 4. Distribution of County-sets 16
Table 5. Average Annual Day Use Estimates 31
Table 6. Benefit Estimates 41

List of Figures

Figure 1. Fort Worth District Reservoir Locations 6
Figure 2. Sacramento District Reservoir Locations 8

SUMMARY

This report presents a methodology for estimating recreation use and recreation benefits at existing and proposed Corps of Engineers reservoirs. It is the outgrowth of recreation use studies instituted by the Office of the Chief of Engineers, Washington, D. C.

Multiple linear regression analysis is employed to develop two regional day use estimating models from recreation use survey data collected at 19 Corps reservoirs in the Fort Worth and Sacramento U. S. Army Engineer Districts. The estimators developed should be applicable for estimating day use at most existing or proposed Corps reservoirs within these regions.

The "travel-cost" model, which employs a "proxy for price" to derive demand schedules from the regional estimators, is presented. The model is illustrated by deriving demand schedules for the study reservoirs and estimating their recreation benefits.

The methodology presented is of considerably greater scope and intensity than other estimating procedures in current use and yields reasonable and useful results. Further improvements and refinements to the technique should result as additional recreation use data are collected and analyzed.

A PRELIMINARY ANALYSIS OF DAY USE RECREATION AND BENEFIT ESTIMATION MODELS FOR SELECTED RESERVOIRS

PART I: INTRODUCTION

General

1. The Flood Control Act of 1944 authorized the Corps of Engineers " . . . to construct, maintain, and operate public park and recreational facilities in reservoir areas." Full consideration of recreation as a project purpose in the planning of multiple-purpose water projects was directed by Senate Document 97 of 1962. The elevation of recreation to a status equal with other purposes necessitated the development of a standardized procedure for estimating recreation benefits which would produce results comparable with the benefits derived for other project purposes. A temporary solution was given in Supplement No. 1 to Senate Document 97, issued by the Ad Hoc Water Resources Council 4 June 1964 (16), which stated as follows:

> The purpose of this supplement is to provide standards, pending further research, for the evaluation of recreation benefits from the use of recreation resources provided by water and related land development projects. Investigations and planning for recreation purposes, including appraisal of recreational values, should be of comparable scope and intensity to studies of other project purposes.

To standardize the treatment of recreation in project planning, the council established unit values as a measure of the recreationists' willingness to pay "Pending the development of improved pricing and benefit evaluation techniques, . . ." The council not only recognized the need for an improved pricing technique but also the need for "Further studies . . . to more clearly define various quantitative and qualitative inter-relationships of recreational uses of resources."

2. The Corps of Engineers acknowledged the need for research in recreation and recognized that the first requirement was a standardized method of obtaining reliable recreation data. In 1962 the Corps initiated a survey procedure for obtaining information on attendance at all Corps administered reservoir projects. In 1966, 52 reservoir projects from seven U. S. Army Engineer Districts were selected for collection of data by a survey modified to provide additional information for research and planning purposes (12). This special study data collection continued through 1969 and provided four full years of recreational use statistics which enable an empirical evaluation of techniques devised to estimate recreation use and benefits.

3. A number of studies have reported techniques for estimating recreation benefits. The majority of these have been endorsements of a general approach known as the travel-cost model (2). This approach uses variable or out-of-pocket travel costs as the proxy for price to construct demand schedules for estimating recreation benefits. Although these studies have demonstrated the technique and produced demand schedules for existing sites, they do not yield a general model from which the planner can estimate benefits for a wide range of proposed projects within a region.

Purpose and Scope

4. The purpose of this study is to demonstrate the feasibility of day use recreation visitation and benefit estimation models which can yield benefit estimates "of comparable scope and intensity to studies of other project purposes." The estimation models discussed herein are intended as a basis for development of an acceptable procedure to be employed by Corps of Engineers recreation planners and others in developing plans for recreation and other aspects of water resources development. The study presents an evaluation of factors potentially influencing recreation use. The goal of the regression analysis of this study differs from most previous applications. Earlier studies were concerned with estimating recreation use and benefits at a specific site. This study is concerned with developing regional models applicable for estimating recreation use and benefits at all existing and proposed U. S. Army Corps of Engineers reservoir projects within the appropriate geographical area. Day use recreation estimators are developed from regression analysis of recreation use survey data collected at 19 reservoirs in the Fort Worth and Sacramento U. S. Army Engineer Districts. The rationale for the construction of demand schedules to estimate benefits is given, and illustrative values are computed.

PART II: DATA DESCRIPTION

The Sites

5. Data from two of the seven districts which participated in the data collection program (12) were selected for use in this study. The 19 reservoirs of these two districts represent a heterogeneous mixture within each district area of both geographical locations (Figures 1 and 2) and physical characteristics (Tables 1 and 2). The results obtained should, therefore, be applicable to proposed reservoirs exhibiting a wide range of physical characteristics at sites within these regions. The districts and their reservoirs are:

a. Fort Worth District:

(1) Belton Reservoir on the Leon River in Bell and Coryell counties, Texas.

(2) Benbrook Reservoir on the Clear Fork of the Trinity River in Tarrant County, Texas.

(3) Dam B Reservoir on the Neches River in Jasper and Tyler counties, Texas.

(4) Grapevine Reservoir on Denton Creek in Denton and Tarrant counties, Texas.

(5) Hords Creek Reservoir on Hords Creek in Coleman County, Texas.

(6) Lavon Reservoir on the East Fork of the Trinity River in Collin County, Texas.

(7) Garza-Little Elm Reservoir on the Elm Fork of the Trinity River in Denton County, Texas.

(8) Navarro Mills Reservoir on Richland Creek in Hill and Navarro counties, Texas.

(9) Proctor Reservoir on the Leon River in Comanche County, Texas.

(10) San Angelo Reservoir on the North Concho River in Tom Green County, Texas.

(11) Whitney Reservoir on the Brazos River in Bosque, Hill, Johnson, and Somervell counties, Texas.

(12) Canyon Reservoir on the Guadalupe River in Comal County, Texas.

b. Sacramento District:

(1) Black Butte Reservoir on Stony Creek in Glenn and Tehama counties, California.

(2) Harry L. Englebright Reservoir on the Yuba River in Nevada and Yuba counties, California.

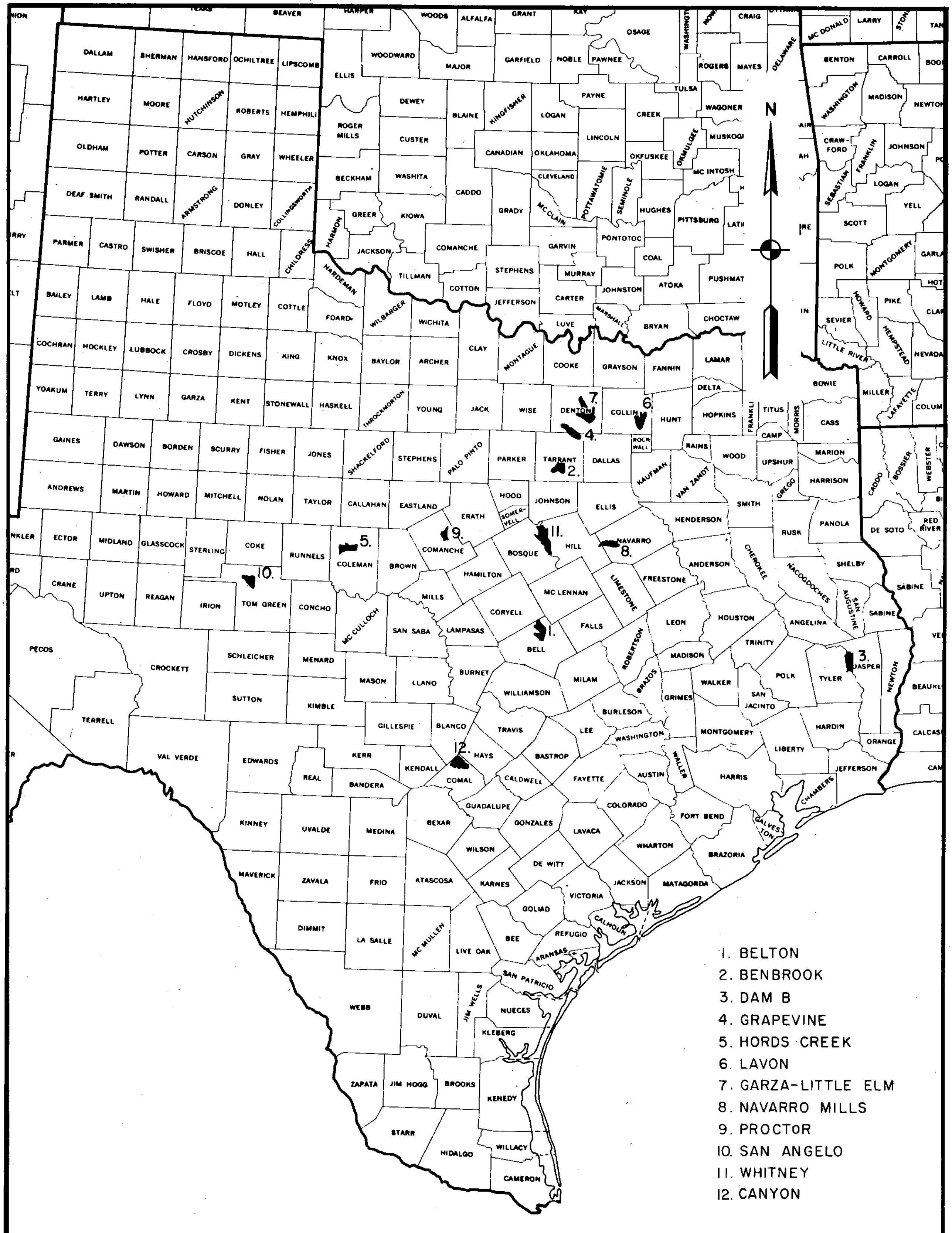
(3) New Hogan Reservoir on the Calaveras River in Calaveras County, California.

(4) Pine Flat Reservoir on the Kings River in Fresno County, California.

(5) Terminus Reservoir on the Kaweah River in Tulare County, California.

(6) Success Reservoir on the Tule River in Tulare County, California.

(7) Isabella Reservoir on the Kern River in Kern County, California.



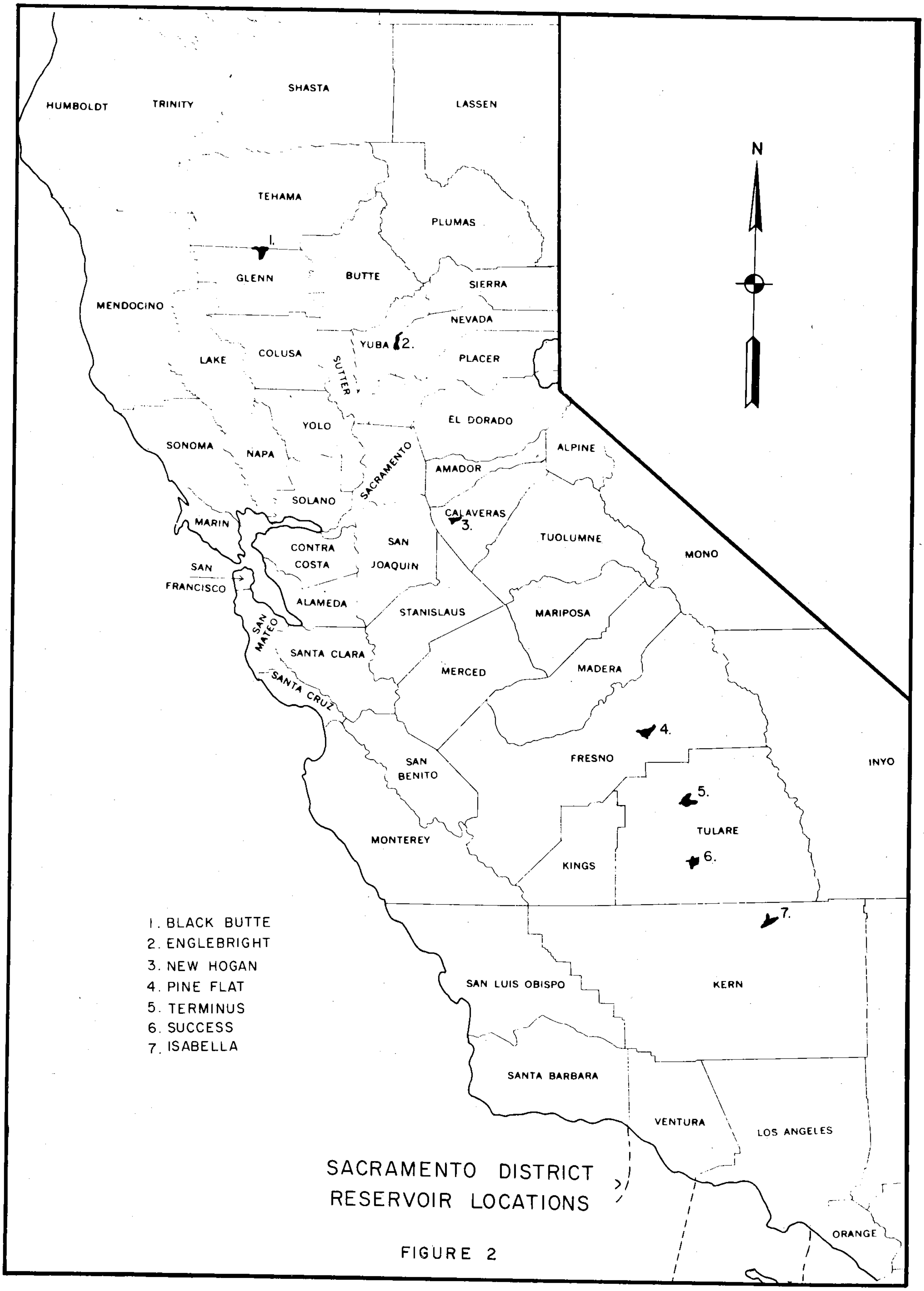
FORT WORTH DISTRICT
RESERVOIR LOCATIONS
FIGURE 1

TABLE 1

SUMMARY OF RESERVOIR DATA - FORT WORTH DISTRICT[a/]

Name of Reservoir	Impoundment Began 1	Reservoir Capacity 2	Average Recreational Pool: Water Area 3	Shoreline 4	Launching Lanes 5	Access Areas 6
	Year	Acre-Feet	Acres	Miles	Number	
Belton	1954	1,097,600	7,400	110	27	13
Benbrook	1952	164,800	3,770	40	22	5
Dam B	1951	124,700	13,700	55	18	8
Grapevine	1952	435,500	7,380	60	24	12
Hords Creek	1948	25,310	510	11	14	3
Lavon	1953	423,400	11,080	83	42	11
Garza-Little Elm	1954	989,700	22,970	183	66	21
Navarro Mills	1963	212,000	5,070	38	12	3
Proctor	1963	374,200	4,610	50	12	4
San Angelo	1952	396,400	5,440	27	29	5
Whitney	1951	1,999,500	16,200	190	73	19
Canyon	1964	740,900	8,240	80	37	7

a/ Additional details of reservoir data are contained in Technical Report No. 2 (13).



SACRAMENTO DISTRICT
RESERVOIR LOCATIONS

FIGURE 2

TABLE 2

SUMMARY OF RESERVOIR DATA - SACRAMENTO DISTRICT[a/]

Name of Reservoir	Impoundment Began 1	Reservoir Capacity 2	Average Recreational Pool: Water Area 3	Average Recreational Pool: Shoreline 4	Average Recreational Pool: Launching Lanes 5	Average Recreational Pool: Access Areas 6
	Year	Acre-Feet	Acres	Miles	Number	
Black Butte	1963	160,000	2,845	25	7	5
Englebright	1941	70,000	750	10	2	2
New Hogan	1963	325,000	2,650	42	3	3
Pine Flat	1954	1,000,000	3,450	53	11	5
Terminus	1962	150,000	570	8	6	5
Success	1961	80,000	600	7	7	6
Isabella	1954	570,000	6,520	30	17	30

a/ Additional details of reservoir data are contained in Technical Report No. 2 (13).

Use Variable

6. Survey estimates of recreation use are made by county of origin for each of the reservoirs included in the study. Survey estimates are derived from the recreation use survey data collected by means of the procedures outlined in Technical Report No. 1 (12). The analysis and development of the day use recreation and benefit estimation models include data for the years 1966-69 for both regions. Because they are data from an enumerative sample survey, the difference between a zero use county estimate and a low use county estimate is in part an artifact of the sampling process. Consequently, the county estimates used in this analysis are averages over the years for which data are available. These estimates tend to reduce any artificial differences between low use counties. Since this is an analysis of day use recreation, a reservoir-county estimate is computed only if the road mile distance between a reservoir and a county is less than 251 road miles, and in the Sacramento District no counties outside California are considered.

7. A previous study by Pankey and Johnston (11), using similar data from the Sacramento District, indicated that more precise total use predictions are obtained by summing a set of estimates by type of use than by using a single total use predictor. For this reason the survey estimates are disaggregated into estimates of day use and camping use. The majority of visitors at most Corps reservoirs are day users, and only the day use estimates are used in this study. A subsequent step will be the development of predictors of camping use for these regions.

The day use estimates are measured in recreation days, defined in Supplement No. 1 as " . . . a visit by one individual to a recreation development or area for recreation purposes during any reasonable portion or all of a 24-hour period." Table 3 summarizes the survey estimates of day use recreation at the 19 projects. Of special interest in Table 3 is the large number of zero observations which remain (the difference between the last two columns), even with the use of average annual estimates.

TABLE 3

SURVEY ESTIMATES OF DAY USE RECREATION

Reservoir	Average Annual Day Use (thousands)	Number of Counties Within 250 Miles	Number of Counties With Non-zero Use Estimates
Fort Worth District		1,775	447
Belton	1,533	134	32
Benbrook	1,912	170	22
Dam B	592	121	49
Grapevine	2,270	172	33
Hords Creek	113	127	31
Lavon	2,510	157	10
Garza-Little Elm	1,968	169	21
Navarro Mills	362	171	48
Proctor	303	155	52
San Angelo	394	126	42
Whitney	2,010	158	29
Canyon	886	115	78
Sacramento District		227	148
Black Butte	161	40	26
Englebright	109	41	17
New Hogan	243	41	29
Pine Flat	493	34	22
Terminus	289	26	21
Success	481	27	20
Isabella	845	18	13

Areal Observation Units

8. The work done by Pankey and Johnston with the California data also indicated that there was little or no statistical preference as between the county and the distance zone as the areal unit of observation. Since county boundaries also define census boundaries, the county areal unit is the more efficient in data processing and was initially selected for use in this study. However, use of the county as the observation unit, although convenient and efficient, is not necessarily optimum. In California the counties are very irregular in size, and in some instances the proximate counties encompass too large an area from which meaningful results can be obtained. In Texas and neighboring states the counties are more uniform in size, and the more distant ones appear too small to be observation units. It was hypothesized that the large, proximate counties could be subdivided by County Census Divisions (CCD) (8) and that the smaller, more distant counties could be clustered to form more meaningful observation units. With these modifications the efficiency of conformance with census boundaries could be maintained, and one advantage of distance zones, controlled size, could be achieved. The results are "county sets" which approximate distance zone segments but whose boundaries coincide with county or CCD boundaries.

9. For the Fort Worth region each county with measured road mile distance of 50 miles or less from a project defines a county set. Counties which are 51 to 150 miles from a reservoir are clustered in groups of 4-5 contiguous counties to define a county set, and counties from 151 to 250 miles are clustered in groups of 7-9 contiguous counties.

The clustering of counties is done in as nearly a circular manner as possible. There are 358 reservoir-county set observations (appendix A) as compared with 1,775 reservoir-county observations. Of the reservoir-county set observations, only 29 percent are zero use compared with 75 percent zero use among the reservoir-county observations.

10. The criterion for delimiting county sets in the Fort Worth region was inapplicable for California due to the irregularity of county size. Thus, rather than specify the number of counties to be clustered within each distance range, county sets were constructed so that the respective ranges had a similar number of observations between the projects. The criterion for the 0-50 mile range is approximately four observations, and for the 51-150 mile and 151-250 mile ranges it is approximately ten observations. The exact number of observations for each project is determined by the surrounding highway network and the proximity of the project to either the California border or large, sparsely populated regions of the state.

11. Before the sets could be constructed for California, it was necessary to subdivide several of the large counties and counties proximate to the reservoirs to maintain the zone segment approach. When this was necessary the CCD's within that county were clustered to form sub-county units, just as the smaller, distant counties were clustered to form sets. The CCD's were grouped with respect to their areal size, population, and proximity to the project and, as with counties, all clusters contain contiguous CCD's. Once the grouping was completed the reservoir-county observations were

replaced for the subdivided counties with reservoir-sub-county observations. The sub-county units were then combined with the remaining undivided counties to develop county sets for California according to the above criteria. This delimited 168 reservoir-county set observations (appendix B) as compared with 227 reservoir-county observations. Only 17 percent of the reservoir-county set observations are zero compared with 35 percent zero use among the reservoir-county observations. Table 4 summarizes the distribution of county sets by reservoir for the two regions.1/

Variables Influencing Use

12. In this analysis a variable is defined by a directly measurable characteristic. Three general classifications of variables considered are county specific measures, reservoir specific measures, and reservoir-county relationships. The variable measurements were initially compiled by reservoir-county observation unit, with each sub-county unit treated as a separate county. County set measurements are then compiled in the following manner. Reservoir specific measurements remain unchanged.

1/ It appears that the concept of a county set can yield reasonable, functional, and near optimum observation units. The particular set definitions used in this analysis are not given as final or optimum. Further research is needed to develop a standard definition applicable for all regions.

TABLE 4

DISTRIBUTION OF COUNTY SETS

Reservoir	County Sets	County Sets with Non-Zero Use Estimates
Fort Worth	358	253
Belton	25	17
Benbrook	38	18
Dam B	24	22
Grapevine	35	25
Hords Creek	25	19
Lavon	33	9
Garza-Little Elm	36	20
Navarro Mills	32	27
Proctor	30	26
San Angelo	28	25
Whitney	28	21
Canyon	24	24
Sacramento District	168	140
Black Butte	23	20
Englebright	23	16
New Hogan	24	20
Pine Flat	26	22
Terminus	24	20
Success	26	23
Isabella	22	19

County set use and population are the sums of the county (or sub-county) measurements within the set. County set median income is defined by the population-weighted mean of the county median incomes within the set. All other variable measurements are the simple means of the measurements for each county within the set. The analysis of variables influencing recreation use includes:

a. County specific measurements

(1) P = county population
(2) M = county population land density
(3) I = county median family income

b. Reservoir specific measurements

(1) L = shoreline miles at average recreation pool
(2) c = accessible shoreline miles
(3) W = water surface area at average recreation pool
(4) A = total project area in acres
(5) V = coefficient of variation of water surface acres
(6) Project land in acres = A - W
(7) Average annual precipitation
(8) Number of days of rainfall
(9) Number of days with wind over 10 miles per hour
(10) Mean depth at maximum pool
(11) Mean depth at average recreation pool
(12) Age of reservoir
(13) Length of growing season in days
(14) An index of circularity = perimeter $\div 2\sqrt{\pi \text{ area}}$

c. Reservoir-county relationships

(1) D = road mile distance between most populous city in the county and nearest reservoir access.

(2) Alternative indices which are attempts at quantifying the influence of alternative water-oriented recreation opportunities on visitation at the projects under study. It would be expected that although the total number of recreation visits from a population would

increase as the number of readily available alternative sites increases, the number of visits to a particular reservoir would decrease. All of the indices tested are essentially gravity variables whose values increase as either the number of alternatives, their size, or their proximity to the population increase. Included are:

(a) $N = \sum_k a_k/d_k^2$

(b) $Q = \sum_k \ln a_k/d_k$ for all $\ln a_k/d_k > \ln a_j/d_j$

(c) $q = \sum_k \ln a_k/d_k$

(d) $S = \sum_k a_k/d_k$ for all $a_k/d_k > a_j/d_j$

(e) $s = \sum_k a_k/d_k$

(f) $T = \sum_k 1/d_k$ for all $d_k < d_j$

(g) $t = \sum_k 1/d_k$

(h)-(n) the above indices + g

where: k denotes any other comparable lake or reservoir within 100 miles of the county (sub-county),

j denotes a survey reservoir,

a = the surface acres at gross pool,

d = the distance between the county and the reservoir or alternative,

g = 0 if the county is more than 100 miles from the coast, or

= 100 - distance from the coast, otherwise.

13. In the analysis of the data from the Fort Worth District, the air mile distance between the county and the lake or reservoir was used for

the compilations of alternative indices. However, preliminary research of the data from the Sacramento District indicated that the California highway network is such, especially in the Sierra Nevada Range, that the road mile distance would be the more appropriate measure. Therefore, road mile distance is used in the compilations of alternative indices for California. The restricted summations, Q, S, and T, are developed from the hypothesis that the recreationist does not consider all lakes or reservoirs as equal alternatives to the projects but emphasizes only those that are closer, T, or more "attractive," Q and S.

14. Even after the forms of the alternative indices have been selected, two measurement problems remain before the actual compilations can be made. First is the problem of identifying those lakes and reservoirs which are truly potential recreation alternatives within a region. The Department of Water Resources of the State of California lists over 1,000 dams within the jurisdiction of that state alone (10). In addition the numerous dams controlled by Federal agencies and the natural lakes within a region must also be evaluated for their potential as alternatives. Those lakes and reservoirs which are either too small to be valid alternatives or are unavailable for recreational use must be identified and deleted from the computations.

15. For the legitimate alternatives the problem of measuring their attractiveness remains. In this study size is used as the measure of attractiveness, an approach appearing often in previous works. However, this does not completely eliminate the problem since a standardized size

measurement, available for all potential alternatives, must be used in the computations. A standardized average annual measurement or an average measurement during the recreation season would seem the most appropriate but, unfortunately, neither was available for all potential alternatives. Therefore, the surface acres at gross pool was used since it is a common measurement available for all recreation alternatives.

PART III: DAY USE RECREATION ESTIMATORS

The Estimator

16. When using the travel-cost approach and the concept of consumers' surplus, the demand schedules, and thus the measure of recreation benefits, are readily derived from the day use estimators. The accuracy of the benefit calculations are, therefore, greatly dependent on the ability to adequately predict day use attendance. For this reason the development of acceptable day use estimators has been a primary objective of this study. As mentioned previously, the study develops two regional day use estimators from a heterogeneous mixture of existing projects within each region. It must be emphasized that the statistical measures of accuracy reported for these estimators are only relevant within the specific regions from which they are developed.

17. Examination of the results of other studies (5, 8, 11, 17) indicates that attempts at derivation of an analytical expression of recreation use typically hypothesize the general form model:

$$Y = B_0 X_1^{B_1} X_2^{B_2} \cdots X_n^{B_n} \, \mathrm{EXP}(E) \tag{1}$$

Where Y = recreation use,

each X_i = a variable affecting use $\quad i = 1, 2 \cdots n$,

each B_i = a parameter to be estimated $\quad i = 0, 1, 2 \cdots n$,

and E = the error term.

The logarithm of Y is then regressed on the logarithms of the X_i in the form:

$$\ln Y = B_0 + B_1 \ln X_1 + B_2 \ln X_2 + \cdots B_n \ln X_n + E \qquad (2)$$

18. This general form model was also hypothesized in this study. Analysis of (1) and (2) yielded the following conclusions.

a. If no zero observations exist or if only the non-zero observations are considered, the regression equation (2) adequately describes the data distribution. However, since zero observations not only exist but can dominate, they must be accomodated. A simple transformation of all zeros into a positive constant is no solution; the equation (2) is then an incorrect specification. The blanket exclusion of the zeros is possible but severely limits the usefulness of the results.[2/]

b. The usual estimator of recreation use employed, $\hat{Y} = \mathrm{EXP}(B_0 + \sum_i B_i X_i)$, is a biased estimator with limited capability. Alternative estimators, which appear preferable to the one usually employed, do exist (4, 9); but experiments with these data resulted in no appreciable improvement in the estimates.

c. Given the primary task that the model is to accomplish, namely, an estimate of average annual use at a proposed reservoir, the error specification admitted in (1) is inappropriate. An expectation of an equal percentage error for all observations should not be sought. Of concern is the accumulated error over a set of observations associated with a particular reservoir. If there exists a relatively small subset of

2/ This approach was investigated with similar data by Pankey and Johnston (11).

these observations, which contributes substantially all of the use (and this is not uncommon), then it is preferable to estimate elements of this subset with a smaller relative or percentage error. For example, a 50 percent error for an estimate of 100 is simply more acceptable than a 50 percent error for an estimate of 100,000.

19. For these reasons, alternative specifications were considered including the straightforward linear model:

$$Y = B_0 + B_1X_1 + B_2X_2 + \cdots + B_nX_n + E \qquad (3)$$

Numerous regressors (the X_i) have been defined in attempts to make this estimator valid. In general these attempts had only limited success. However, as described below they did lead eventually to the following specification which is regarded as an appropriate description of the relationships sought.

$$Y = \alpha + Z\ (B_0 + B_1X_1 + B_2X_2 + \cdots + B_nX_n) + E \qquad (4)$$

This estimator, when considering both validity and reliability, has general applicability, and it is this estimator that is used in this report.

20. Linear estimators with the usual variable specification (each regressor consists of the measurements of just one independent variable) fail to account for any multiplicative influence of the independent variables. Estimators derived from such variable specifications explain a relatively low percentage of the total variation in the survey estimates of recreation use and are not sufficiently precise for the derivation of recreation benefits for planning purposes. For these reasons this

study has experimented with different variable specifications which attempt to incorporate into straightforward linear estimators the multiplicative influence of several of the independent variables.

21. The first modification in variable specification tested was an estimator for which all regressors were cross-products between population and one of the remaining independent variables. For those variables exhibiting a positive correlation with use the regressors were simple cross-products, while for those variables negatively correlated with use the regressors were cross-products between population and the inverse of the variable's measurements. During the analysis of these estimators it was realized that the regresor, population/distance (P/D), explained more of the variation in recreation use by itself than any of the linear estimators previously developed with the usual variable specification.[3/] Subsequent analysis indicated that further improvements in the estimators could be realized when each of the regressors was developed from a cross-product between P/D and one of the remaining independent variables. The Fort Worth and Sacramento regional estimators are developed from this form of variable specification.

3/ It also explained more variation that any exponential estimator if the appropriate squared errors are considered.

Recreation Day Use Estimator - Fort Worth Region

22. The Fort Worth regional estimator is:

$$Y_{ij} = -\ 2{,}749 + (P_i/D_{ij})\ (.0002A_j\ -\ .1694D_{ij}\ +\ 269{,}053I_i^{-1}\ -\ 15.7970T_{ij}) \quad (5)$$

$$R^2 = 0.672 \qquad (22.07) \qquad (70.52) \qquad (24.81) \qquad (5.64)$$

where i denotes the county set of origin, and j denotes the reservoir. Two statistical measures are reported above and include the F-values, the values in parentheses below the regression coefficients, and the coefficient of determination, R^2. The F-statistic is used to test the hypothesis that the regression coefficient is zero, that is, that the respective regressor has no linear influence on Y.[4/] For 353 degrees of freedom an F-value greater than 5.02 indicates that the coefficient is significant at 2.5 percent, which means that the probability is less than 2.5 percent that the coefficient should be zero. For the Fort Worth estimator all F-values exceed 5.02 and are, therefore, significant at 2.5 percent. The other statistic, R^2, measures the proportion of total variation about the mean of the observations that is explained by the regression equation. Thus, the R^2 of 0.672 indicates that slightly over two-thirds of the total variation among the observations of recreation day use for the Fort Worth region can be explained by this estimator.

4/ Recall that the regressors are products of P/D and another independent variable; thus the regression coefficient .0002 is the coefficient for the regressor, PA/D, with the corresponding F-value 22.07.

23. The Fort Worth regional estimator contains the independent variables population, road mile distance, total project area, median family income, and the alternative index, T. From the signs of the regression coefficients and the transformations of the variables, it is clear that total project area is positively correlated and income and the alternative index negatively correlated with use. For total project area and the alternative index these results agree with a priori assumptions as to the influence of these variables. However, the negative influence of the variable income was not expected. A similar relationship between income and use was also observed during the analysis of variables for the Sacramento region. This correlation could be attributable to a number of sources. Except for some experimental programs at a few selected reservoirs during the summer of 1968, there were no entrance charges for day use at the Corps reservoirs during the years of the survey. However, during the same period, day use entrance fees per person or per car were common at many of the competing reservoir areas. Thus, the negative correlation between use and income could reflect a tendency for the lower income families to visit the reservoirs at which no entrance fee was required. In addition, the possibility exists that the average income measure used, median family income for the areal unit, serves as proxy for some other highly correlated variable.

24. The correlations between population and use and distance and use are not readily apparent from the regional estimator but can be determined

by substituting actual measures of the remaining independent variables. For example, the median measures of A, I, and T are 18,000, 4,900, and 1.215, respectively. Substituting these values into the estimator and factoring yields:

$$Y = -2{,}749 + P(-.1694 + 39.3148D^{-1}) \tag{6}$$

From this equation it can be seen that distance exhibits a consistent negative correlation with use while population is positively correlated throughout the distance range 0-231 miles. Since the largest distance measure for the county sets from which the estimator is developed is 224 miles, population exhibits a consistent positive correlation, given median values of the remaining variables. However, given the form of the estimator, there are a minimal number of observations (less than 10 percent) for which the remaining independent variables are such that population will exhibit a negative correlation with use. The inability of the estimator to correctly quantify the interrelationships between the independent variables for these few observations is but a small detriment in comparison to the overall precision gained through its use.

Recreation Day Use Estimator - Sacramento Region

25. The Sacramento regional estimator is:

$$Y_{ij} = -4{,}285 + (P_i/D_{ij})(-2.66 + .0014W_j + 28Q_{ij}^{-2}) \tag{7}$$

$$R^2 = 0.929 \qquad (107.3) \quad (495.2) \quad (1198.8)$$

For the Sacramento estimator with 164 degrees of freedom the F-values signify that all regression coefficients are significant at 0.5 percent, and the coefficient of determination indicates almost 93 percent of the total variation is explained by the estimator. Again, a project size measure, water surface area, is positively correlated with use; and an alternative index, Q, is negatively correlated. It can also be shown that, as with the Fort Worth estimator, population is, in general, positively correlated with use and distance negatively correlated.

A Comparison of the Regional Estimators

26. The estimator presented for each region is but one of many which explain variations in use for that region with similar statistical accuracy. The remaining estimators can be developed from those presented by substituting similar independent variables (e.g., substituting land area for total project area in the Fort Worth estimator); by substituting different transformations of the independent variables (e.g., replacing Q^2 with Q in the Sacramento estimator); and by adding subsequent regressors. The two estimators presented were selected with consideration given to the amount of variation explained, the significance of regression coefficients, the correlation of the independent variables, the residual distributions, and the adaptability for use by Corps recreation planners.

27. The coefficients of determination measure the proportion of the total variation of all observations explained by the regional estimators. They are not the pertinent statistics when measuring the variation over a set of observations associated with an individual reservoir. However, in

general, the more precise the estimator over the region, the more accurate the estimates for an individual reservoir. This is illustrated in Table 5 which compares the survey estimates of use for each reservoir to the use estimates derived from the respective regional estimator.

28. It is clear from Table 5 and from their respective R^2 values that the Sacramento estimator has achieved a greater precision than Fort Worth's. Although the analysis for Fort Worth has been more extensive than for Sacramento, the results are not nearly as satisfying. The range and distribution of survey estimates for the Fort Worth District are simply less amenable to analysis. The range of estimates for Fort Worth is zero to 1,815,550 with 29 percent zeros. This compares with zero to 363,447 with 17 percent zero estimates for Sacramento. For one reservoir, Lavon, in the Fort Worth region only nine of its 33 county set observations have non-zero use estimates. Given such a distribution of the dependent variable, it is surprising that the regression estimator can explain as much as two-thirds of the variation.

29. In general, examination of the recreation use survey data collected indicates that they are adequate, but imperfections and variations in quality do exist. Such imperfections and variations emphasize the importance of precision and quality required in future data collection. Careful application of the procedures specified in Technical Report No. 1 (12) is a necessity. In data manipulation, there are variations also; in the Sacramento analysis, for example, the analysts' familiarity with California

enabled helpful subjective judgments in the construction of county sets and alternative indices which were not possible in the Fort Worth analysis.

30. Another factor which should improve both estimators will be the use of the 1970 census data as they become available. The population estimates used in this study were estimates for 1966 published by the Bureau of the Census (14). Early reports indicate that for many regions the populations as measured by the 1970 census differ significantly from the yearly projection estimates that had been made. Thus, the 1970 data should enable more accurate estimates of the population to be developed for the survey period for both regions.

TABLE 5

AVERAGE ANNUAL DAY USE ESTIMATES

Reservoir	Survey Estimate (thousands)	Regional Estimator (thousands)
Fort Worth District		
Belton	1,533	786
Benbrook	1,912	2,714
Dam B	592	725
Grapevine	2,270	1,880
Hords Creek	113	11
Lavon	2,510	1,613
Garza-Little Elm	1,968	3,097
Navarro Mills	362	807
Proctor	303	404
San Angelo	394	644
Whitney	2,010	1,244
Canyon	886	930
Sacramento District		
Black Butte	161	176
Englebright	109	81
New Hogan	243	276
Pine Flat	493	625
Terminus	289	241
Success	481	440
Isabella	845	782

PART IV: DEMAND AND BENEFIT ESTIMATION

Willingness To Pay

31. Even though outdoor recreation is usually provided as a public service and is, therefore, not distributed to the consumers through the usual market mechanisms, its value can still be measured by what the recreationists are willing to give up to attain it. Thus, the operational definition of the value of outdoor recreation is simply the individual user's willingness to pay for the use of such resources rather than go without them. It is this willingness to pay rather than what they actually pay that is the measure of the benefits received (7). An estimate of these benefits for a project can be computed by measuring the area under the project's demand schedule (curve) which is derived from the regional estimator. A simple hypothetical example should indicate why and how the demand schedules are computed.[5/]

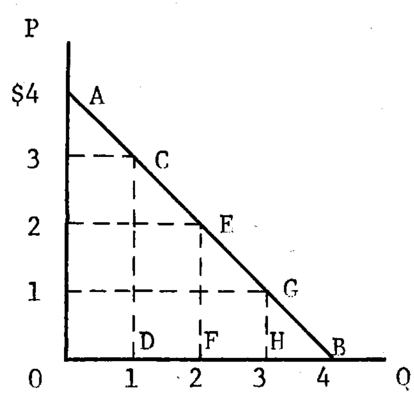


Figure 3

5/ The following synopsis on demand schedules and benefit estimation is developed from a more descriptive analysis presented by Jack Knetsch (7).

The curve AB in Figure 3 is the demand schedule for this particular commodity and indicates the various quantities, Q, that consumers would desire at varying prices, P. Such a demand schedule can be constructed for recreational day use with the quantity demanded measured in recreation days. From this curve it can be readily seen that at a zero price, four units will be demanded (when $P = 0.0$; $Q = 4$). Similarly, at a price of one dollar, three units will be demanded; at two dollars, two units; at three dollars, one unit; and no units at a price of four dollars or more.

32. The measure of the consumers' willingness to pay, or the amount they would be willing to give up to obtain the commodity, is represented by the area under the demand schedule. Thus, from the demand schedule AB in Figure 3, it can be seen that at a price of four dollars the consumers will not purchase any of the product, while at a price of three dollars one unit will be purchased. Therefore, the consumers are willing to pay less than four dollars but possibly more than three dollars for this first unit of the commodity. With the straight line demand curve in Figure 3 the willingness to pay is assumed to be \$3.50 for this unit, represented by the area OACD. Similarly, the area CDEF, equal to \$2.50, represents the consumers' willingness to pay for the second unit; EFGH for the third; and GHB for the fourth. The total willingness to pay by the consumers for the four units of the commodity that would be taken if no price were charged is represented by the area OAB (equal to eight dollars). Thus, once the demand schedule for a

project has been constructed, the recreation benefits, as measured by the recreationists' total willingness to pay, can be readily derived by computing the area under this curve.

Variable Travel Costs - A Proxy for Price

33. The estimate of recreation day use for a project derived from the regional estimator yields an initial point on the project's demand schedule. This point is the quantity of use (in recreation days) that would be demanded at a zero price. (In the example of Figure 3, the point is where P = 0.0 and Q = 4.) To find sufficient points to determine the entire demand curve, it is necessary to make small incremental changes in the price of recreation and to measure the quantity of use that would be demanded given these changes. Unfortunately, it would be impractical to actually make incremental increases in fees at the projects and to take all of the surveys that would be required to measure the influence of such increases in prices. However, the results can be approximated with the use of a proxy for price.

34. Most frequently the variable travel costs have been used as the proxy for price. When using this approach, the regional estimator includes the distance between the project and the site of origin of the user as one of the independent variables influencing use. After the initial estimate of use is made, small increments (e.g., one mile) are added to the distance measurement between the project and each site of origin. This is equivalent to moving the project further and further

from the users, requiring them to pay more and more in travel costs to reach the project. As distance increases, use decreases, and for each increment in distance a new use estimate is computed with the regression equation. The new use estimates are the various quantities of recreation that would be demanded at increasing prices. To determine the price at which these quantities are demanded, it is only necessary to convert the incremental increases in distance to the costs that would be incurred by the recreationists if they were required to travel the additional mileage. The conversion of mileage to price is readily accomplished by the use of published results on the average costs of operating motor vehicles.

35. For this analysis results from a national study by the U. S. Department of Transportation (15) were used as follows:

Variable Cost	Cents Per Mile
Repairs and Maintenance	1.79
Replacement Tires and Tubes	.23
Gasoline	1.50
Gasoline Tax	.73
Oil	.23
Oil Tax	.01
Taxes on Tires, Tubes, etc.	.19
Total	4.68

The variable costs of 4.68 cents per mile reflects the average out-of-pocket cost per mile to operate an automobile in the United States and does not include such fixed costs as depreciation, insurance, registration, etc. However, two adjustments are required before this cost can be used as the proxy for price. The first is an adjustment for round trip mileage.

Since the distance measure used in the regression analysis is the one-way mileage while the recreationists must incur the variable costs while traveling to and from the project, the cost per mile is doubled.

36. Since more than one recreationist arrives in each vehicle, a second adjustment must be made to distribute the travel costs of the trip between the number of recreationists within each vehicle. This is approximated by the use of the load factor (average number of recreationists per vehicle) as determined by the survey questionnaires (12, 13). For the Fort Worth region the load factor is 2.74 and the average cost per person per mile traveled from the site of origin to the project is 3.42 cents. For California the load factor is 3.21 and the proxy for price is 2.92 cents. With the use of these proxies, visitation can be measured as a function of the money costs (prices) for the construction of demand schedules.

An Adjustment for the Disutility of Time

37. The use of just the variable travel costs in the development of the demand schedules ignores the disutility of time which is an important consideration to the recreationist in overcoming distance. When time is ignored the demand schedules are constructed under the hypothesis that increasing distance decreases use only because there is then a higher money cost. However, the additional time required to travel the increased distance would seem to be an equal or greater deterrent to the recreationist than the out-of-pocket money costs. The exclusion of the

time factor introduces a consistent bias in the derived demand schedule, shifting it to the left of the true demand schedule resulting in an underestimation of the recreation benefits (1).

38. However, by making two basic assumptions about the rationale of the users a variable can be formulated containing both time and money costs with which the measurements of time can be held constant while the impact on use due to changes in the money costs are measured. The first assumption required is that the consumers do make a trade-off between time and money costs. That is, other factors being equal, there are many combinations of varying time and money costs for which equal rates of attendance can be expected. Again, a brief example should be helpful.

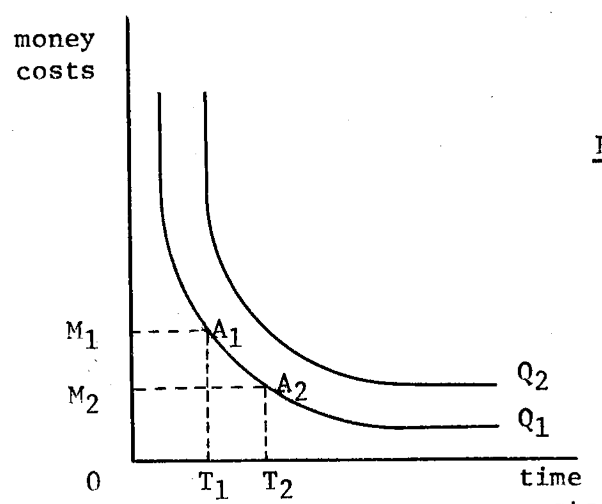


Figure 4

39. By definition each curve in Figure 4 represents points of equal visitation and indicates the various combinations of time and money costs at which these quantities of use would be expected. The curves are but two of a whole family of such curves each representing a different quantity of use, which decreases as the curves move to the right away from the origin. Thus, the use represented by Q_1 is greater than that represented by Q_2. Users at A_1 would incur money costs equal to OM_1 and time costs equal to OT_1 while traveling to the project. The assumption of the trade-off function indicates that, other factors being equal, the users at A_2 faced with lower money costs equal to OM_2 and higher time costs equal to OT_2 would visit the project in the same numbers, Q_1, as those at A_1. Thus, the consumers would be willing to incur additional time costs equal to T_1T_2 to reduce money costs by M_1M_2 or vice versa. Any trade-off of time costs other than T_1T_2 for the money costs M_1M_2 would shift the users to a new curve, and a new amount of visitation would be expected.

40. The second assumption requires that, as the size of the consumers' investment in either time or money costs increases, the impact of further changes in the respective cost factor on the trip decision decreases. In other words, an additional increase of ten cents in money costs will have less of an effect on a trip decision for which the money costs are already ten dollars than for one for which the costs are one dollar.

Similarly, a small change in time costs will have less of an impact on trip decisions involving long outlays of time than on short trips. The assumption of diminishing marginal influences of time and money costs requires that the curves in Figure 4 be convex to the origin.

41. The assumption of the trade-off between time and money costs enables a function of the two factors to be formulated. The requirement of convexity to the origin dictated by the latter assumption indicates a mathematical form which can be used to approximate the true function. Thus, the trade-off function is specified by (CT) where C indicates money costs and T time costs. With the use of the trade-off function the time factor can be held constant during the construction of the demand schedules, resulting in closer approximations of the true schedules than those constructed when time is ignored. A further example should explain why it is important that time not be ignored.

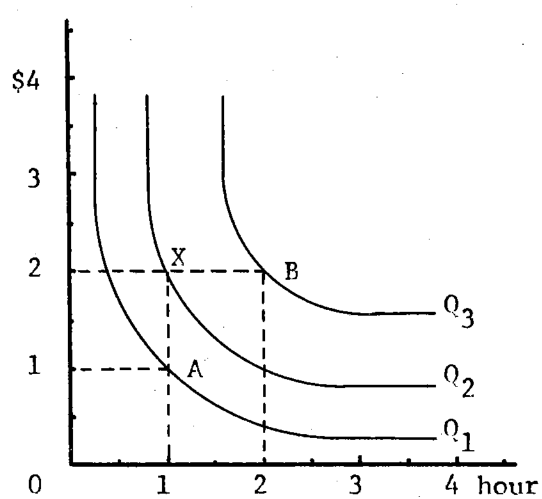


Figure 5

42. In Figure 5, A and B represent two sites of origin from which Q_1 and Q_3 are the respective estimates of use for a project. For A the money costs are one dollar and the time costs are one hour, while for B they are two dollars and two hours, respectively. All other factors are equal. If the time factor is ignored, when incremental money costs are added to A to the point where its total money costs equal two dollars, its new use estimate will be the same as for B or Q_3. However, if the time factor is held constant at one hour while travel costs are incremented to two dollars, use will be expected to decrease but not as much as before. Point X will then give a truer estimate of the actual use, represented by Q_2. Remembering that the quantity of use represented by the curves decreases as they move further right of the origin, it can be seen that if only the effect of increases in money costs are being measured Q_3 will underestimate the actual use and will, therefore, produce an underestimate of the true recreational benefits.

Benefit Computations for the Study Reservoirs

43. Assuming the trade-off function, (CT), between time and money costs and the proxies for money costs developed earlier, the regional estimators are used to develop demand curves for each of the study reservoirs. The area under each demand curve is then computed and taken as the respective reservoir's measure of economic benefits attributable to day use recreation.[6/] The economic benefits of the 19 reservoirs are summarized in Table 6.

6/ See appendix C for an example of the benefit calculations.

TABLE 6

BENEFIT ESTIMATES

Reservoir	Regression Estimate (thousands)	Benefit Estimate (thousands)
Fort Worth		
Belton	786	$2,039
Benbrook	2,714	6,168
Dam B	725	1,875
Grapevine	1,880	5,408
Hords Creek	11	1
Lavon	1,613	4,776
Garza-Little Elm	3,097	9,854
Navarro Mills	807	1,670
Proctor	404	529
San Angelo	644	631
Whitney	1,244	4,142
Canyon	930	2,629
Sacramento District		
Black Butte	176	$ 480
Englebright	81	70
New Hogan	276	980
Pine Flat	625	2,067
Terminus	241	700
Success	440	991
Isabella	782	2,868

6/

PART V: CONCLUSIONS

44. Regional models capable of predicting recreation use at a proposed reservoir can be constructed. The technique demonstrated regresses recreation use survey estimates on variables of the form PX/D, where P is population, D is road mile distance, and X is any other variable affecting use.

45. Theoretically, there exists for each reservoir a demand schedule which precisely describes the recreationist's willingness to pay. This schedule can be approximated from the regional use prediction models by using out-of-pocket travel costs and acknowledging the effect of the disutility of travel time.

46. The value of recreation as an economic good is reported to be identical to the amount that recreationists would be willing to pay. The net benefit provided by a recreational facility is that value, the total willingness to pay, less any direct payments. This net benefit is equal to the area under the derived demand schedule. Thus, derived demand schedules can be used justifiably to estimate recreation benefits at an existing or proposed reservoir project.

47. The estimating process can be replicated and the technique can be usefully employed by Corps of Engineers recreation planners. However, recreational use data of increasing quality are required as input.

References

(1) Cesario, F. J. and Knetsch, J. L., "The Time Bias in Recreation Benefit Estimates," Water Resources Research, Volume 6, No. 3, 1970.

(2) Clawson, M., Methods of Measuring Demand For and Value of Outdoor Recreation, Resources for the Future, Inc., Reprint No. 10, 1959.

(3) Clawson, M. and Knetsch, J. L., Economics of Outdoor Recreation, Baltimore: The Johns Hopkins Press, 1966.

(4) Goldberger, A. S., "On the Interpretation and Estimation of Cobb-Douglas Functions," Econometrica, Volume 36, July-October, 1968.

(5) Grubb, H. W. and Goodwin, J. T., Economic Evaluation of Water-Oriented Recreation in the Preliminary Texas Water Plan, Texas Water Development Board Report No. 84, 1968.

(6) Johnston, W. E., "Report of Research to Sacramento District, U. S. Army Corps of Engineers," Unpublished Report, 1968.

(7) Knetsch, J. L., "Demand and Benefit Estimation for Outdoor Recreation at Corps Reservoir Projects," Unpublished Report, 1969.

(8) Merewitz, L., Estimation of Recreational Benefits at Some Selected Water Development Sites In California, (Berkeley, California, Planametrics, 1968) Office of Water Resources Research, U.S.D.I., Contract No. 14-01-0001-1958.

(9) Pankey, V. S., "Recreation Demand at Large Reservoirs in California," Unpublished Ph.D. Dissertation, University of California, Davis, 1968.

(10) State of California, Department of Water Resources, Dams Within Jurisdiction of The State of California, Bulletin No. 17-68, 1968.

es

References (Continued)

(11) U. S. Army Corps of Engineers, "Analysis of Recreational Use of Selected Reservoirs in California," Plan Formulation and Evaluation Studies-Recreation, Contract Report No. 1 (prepared by V. S. Pankey and W. E. Johnston, University of California, Davis, Department of Agricultural Economics), July 1969.

(12) U. S. Army Corps of Engineers, "Evaluation of Recreation Use Survey Procedures," Plan Formulation and Evaluation Studies-Recreation, Technical Report No. 1, 1969.

(13) U. S. Army Corps of Engineers, "Estimating Initial Reservoir Recreation Use," Plan Formulation and Evaluation Studies-Recreation, Technical Report No. 2, October 1969.

(14) U. S. Department of Commerce, Bureau of the Census, Current Population Reports: 1966: Population Estimates, Series P-25.

(15) U. S. Department of Transportation, Cost of Operating An Automobile, 1968.

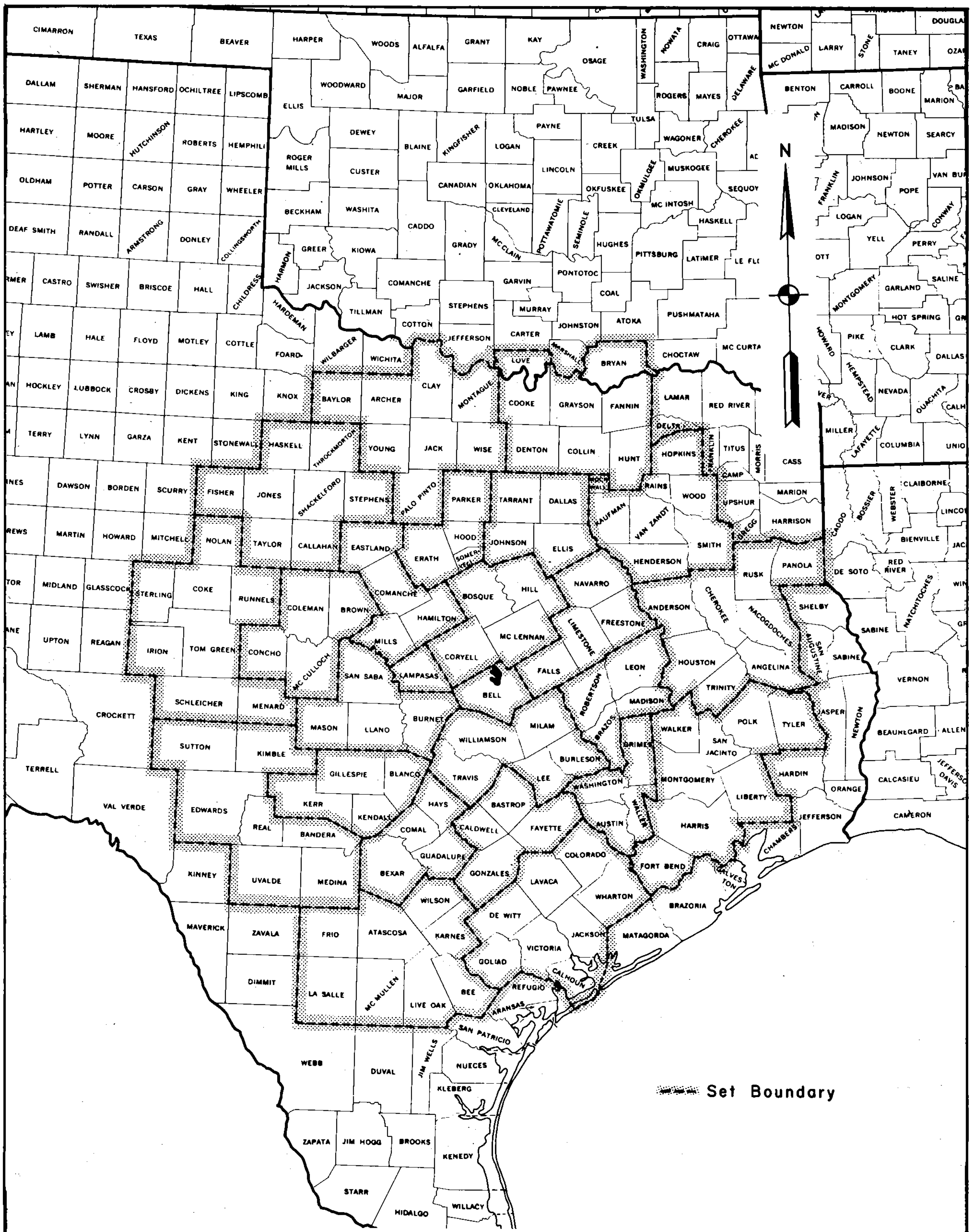
(16) U. S. Senate, Policies, Standards, and Procedures in the Formulation, Evaluation, and Review of Plans for Use and Development of Water and Related Land Resources, Document No. 97, Washington: Government Printing Office, 1962, and Supplement No. 1, "Evaluation Standards for Primary Outdoor Recreation Benefits," 4 June 1964.

(17) Wennergren, E. B., Value of Water for Boating Recreation, Logan: Utah Agriculture Experiment Station Bulletin 453, 1965.

APPENDIX A

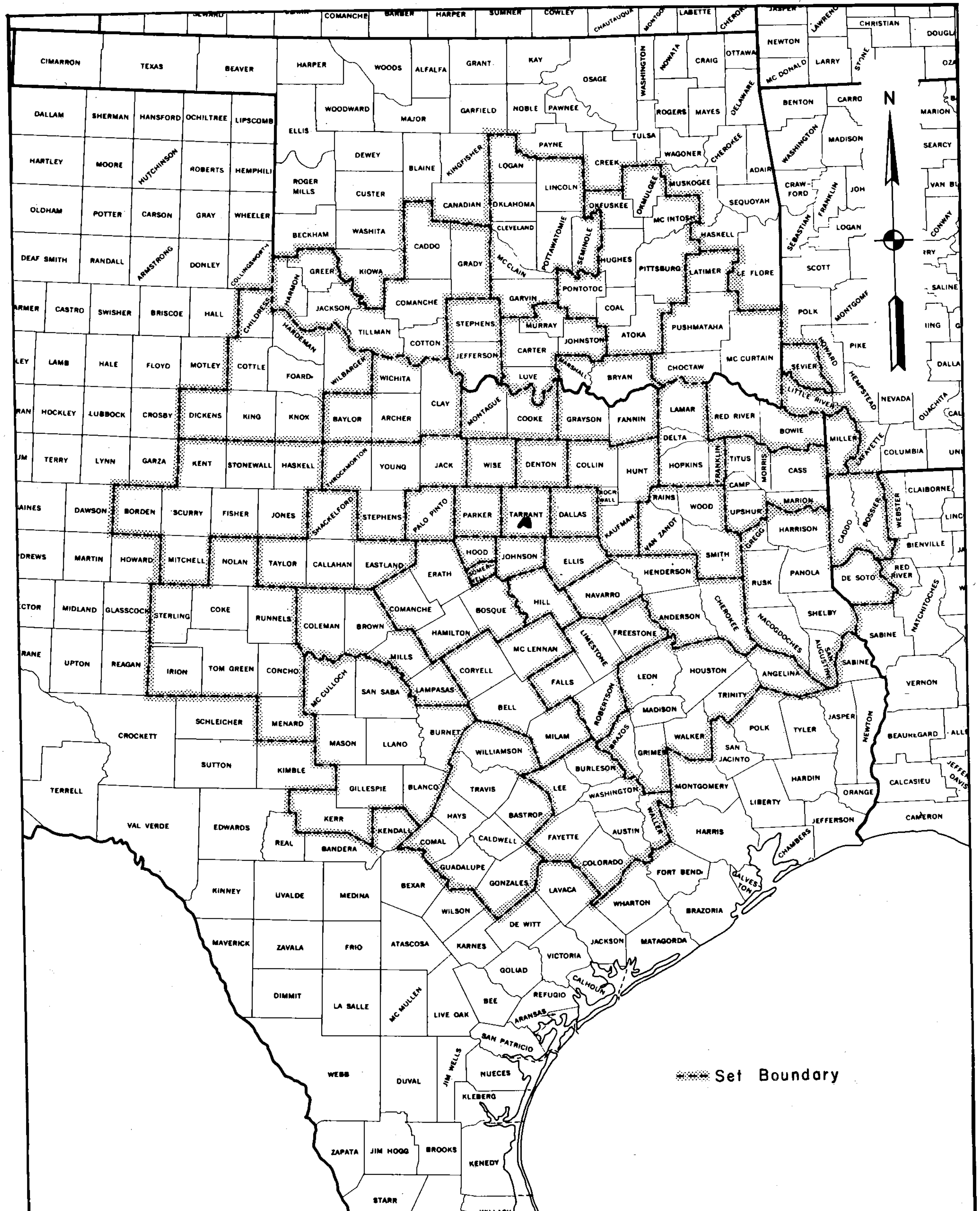
County Sets for Fort Worth Region Reservoirs

Figure	Reservoir - County Sets
A-1	Belton
A-2	Benbrook
A-3	Dam B
A-4	Grapevine
A-5	Hords Creek
A-6	Lavon
A-7	Garza-Little Elm
A-8	Navarro Mills
A-9	Proctor
A-10	San Angelo
A-11	Whitney
A-12	Canyon



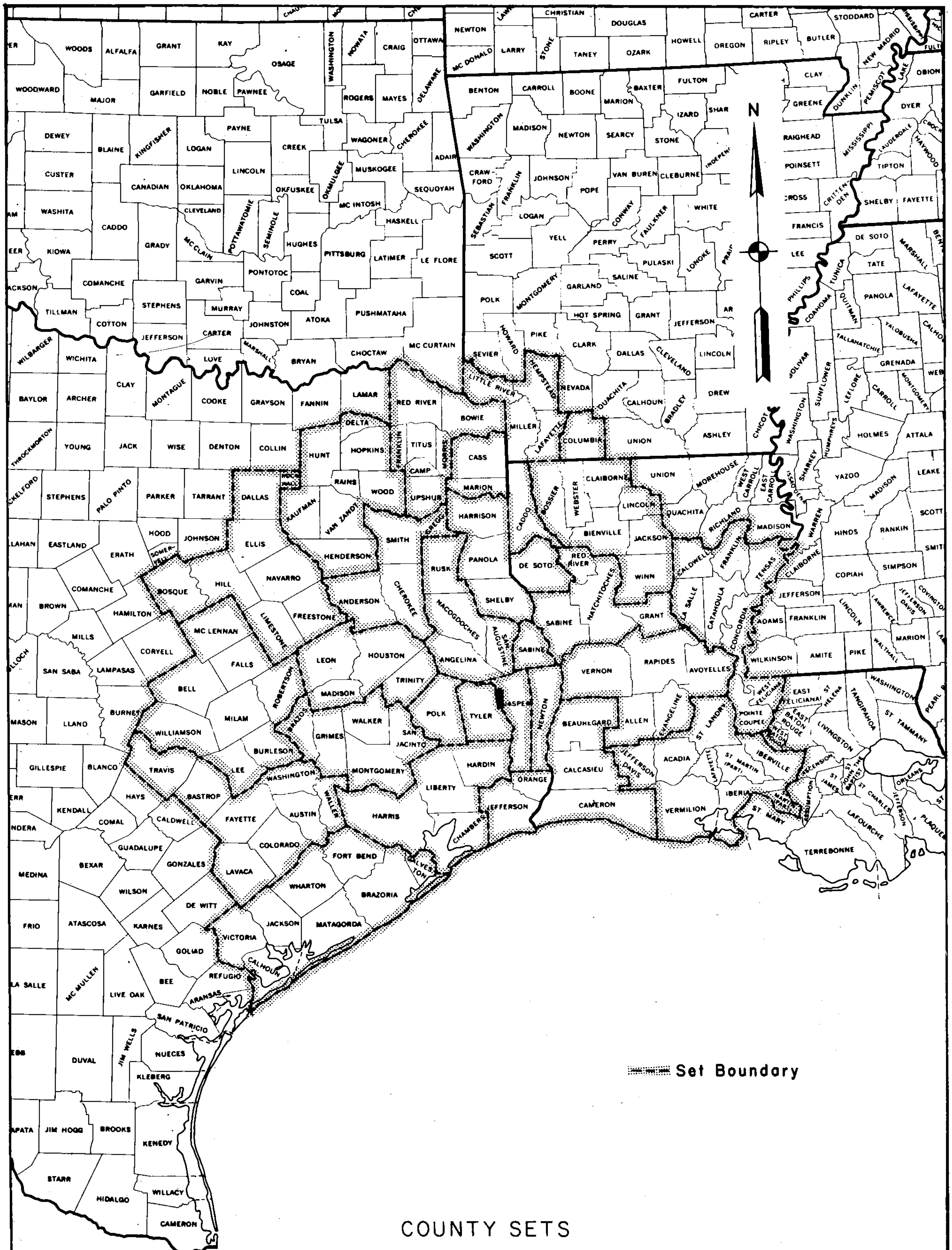
COUNTY SETS
BELTON RESERVOIR

FIGURE A-1



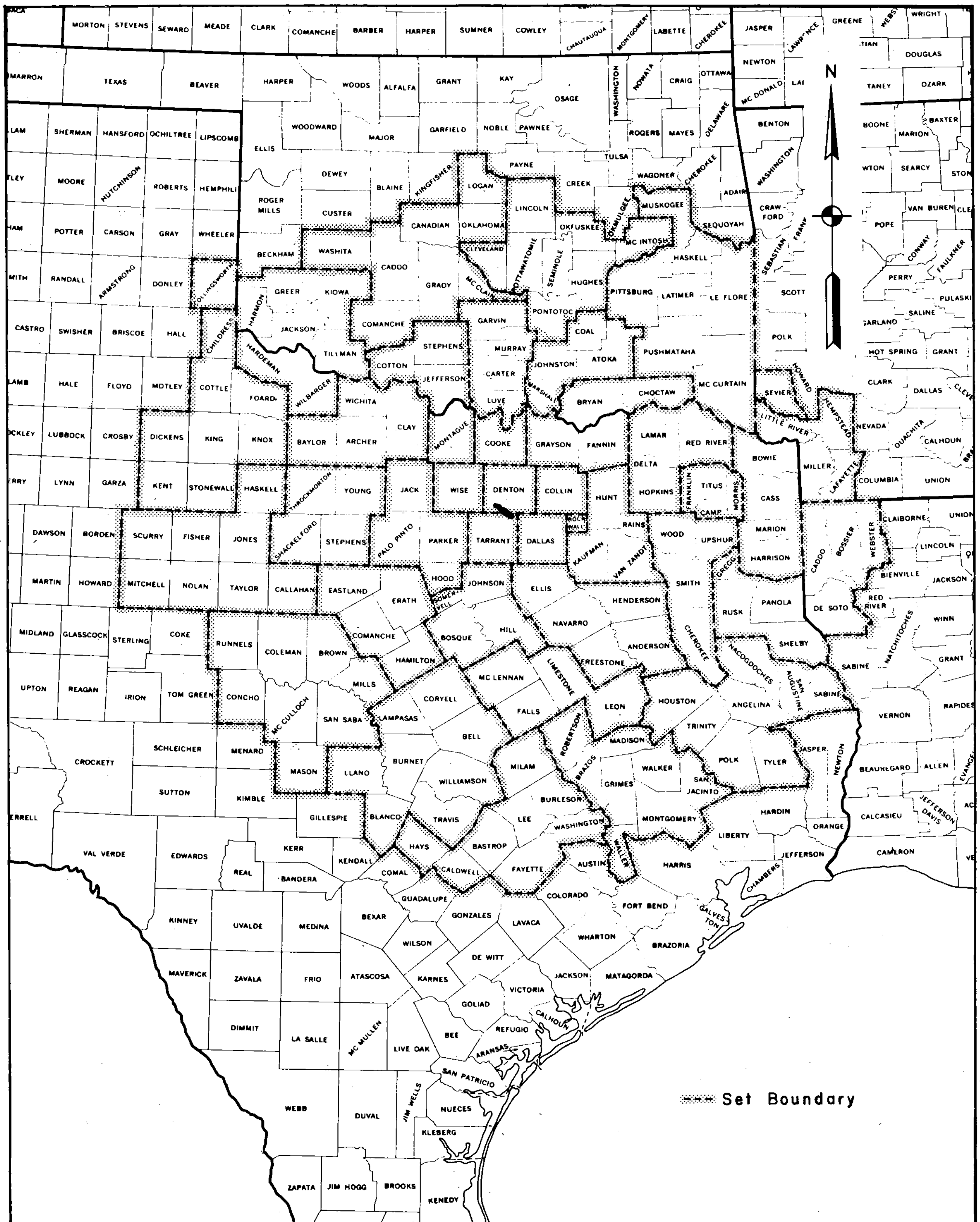
COUNTY SETS
BENBROOK RESERVOIR

FIGURE A-2



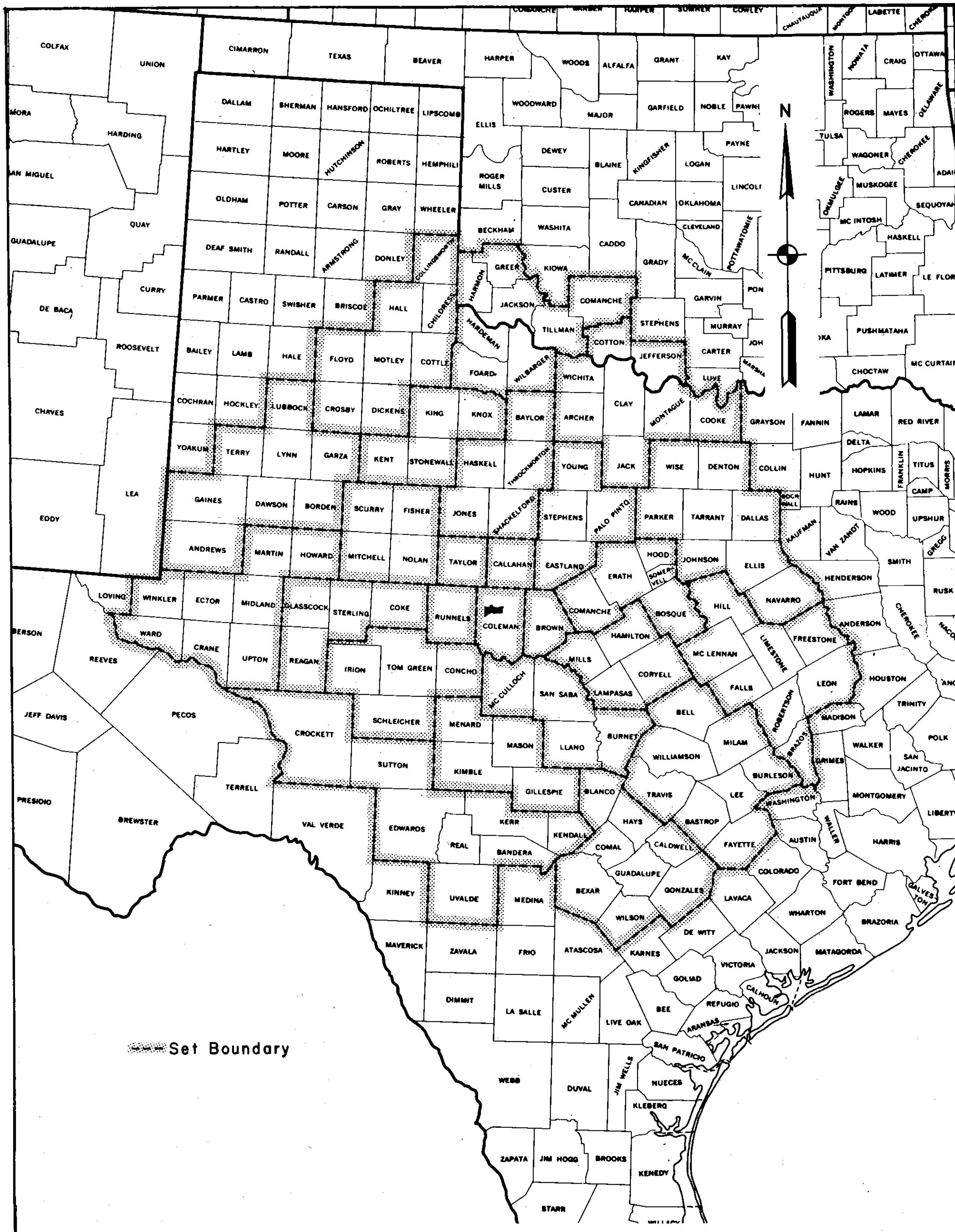
COUNTY SETS
DAM B RESERVOIR

FIGURE A-3

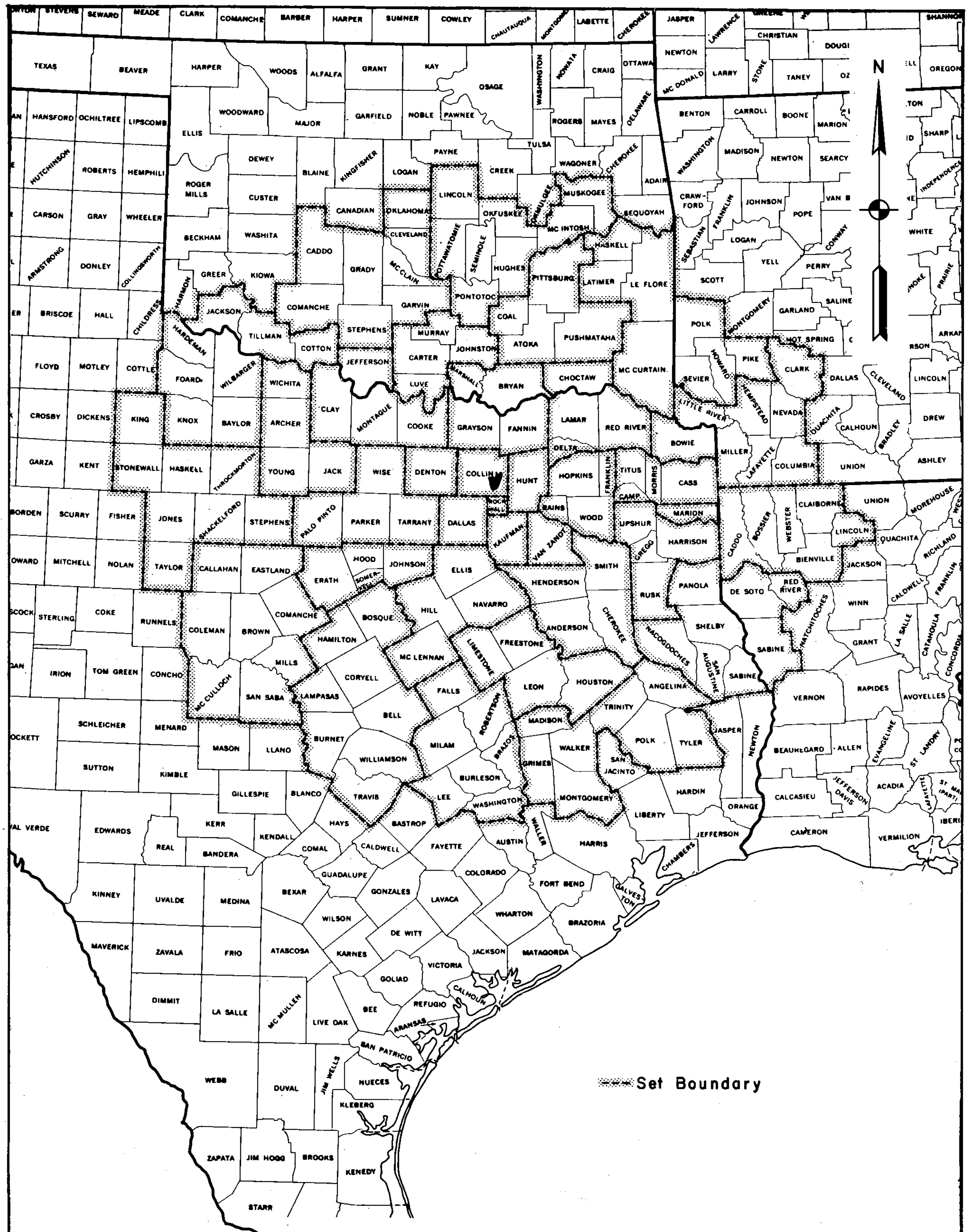


COUNTY SETS
GRAPEVINE RESERVOIR

FIGURE A-4

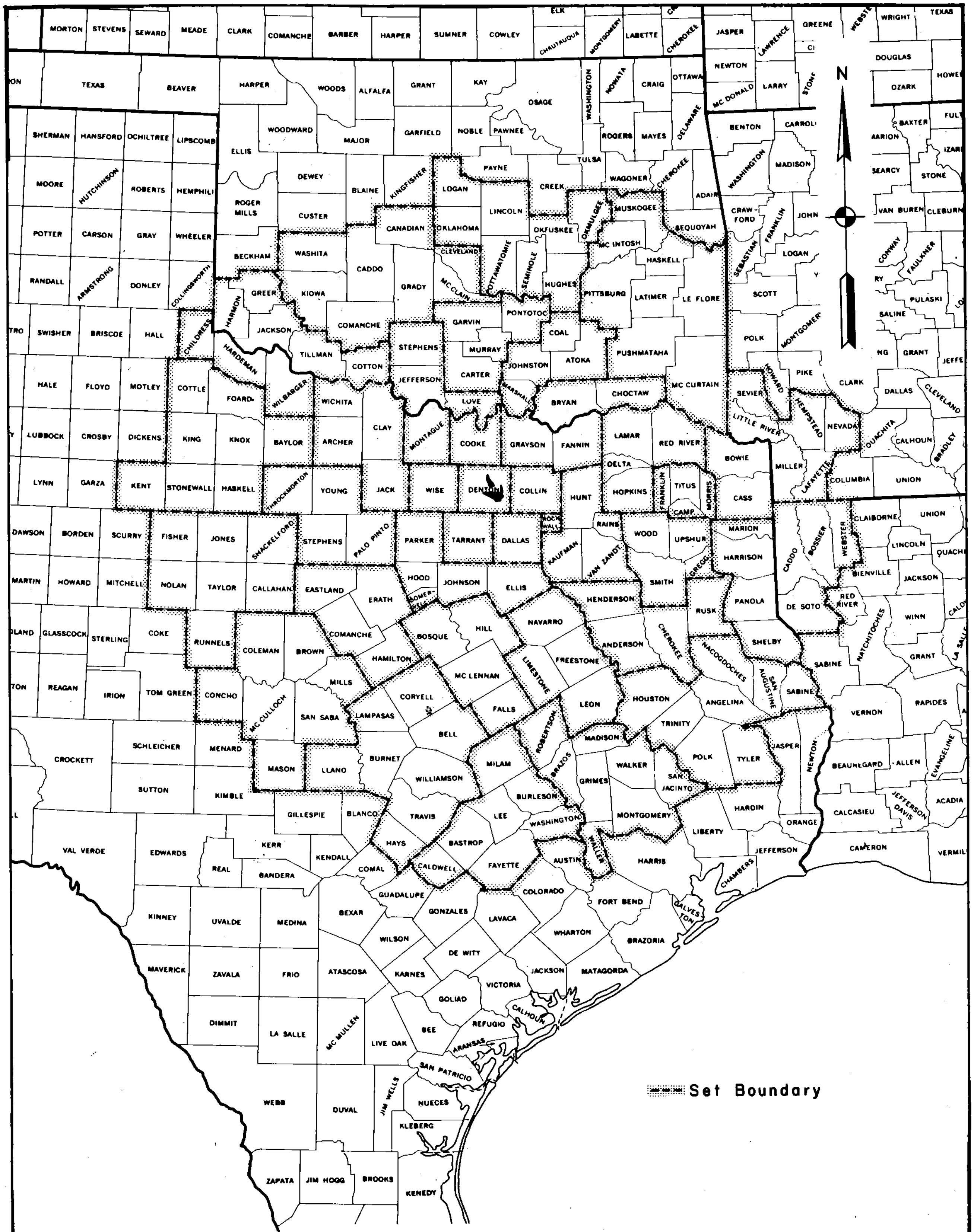


COUNTY SETS
HORDS CREEK RESERVOIR
FIGURE A-5

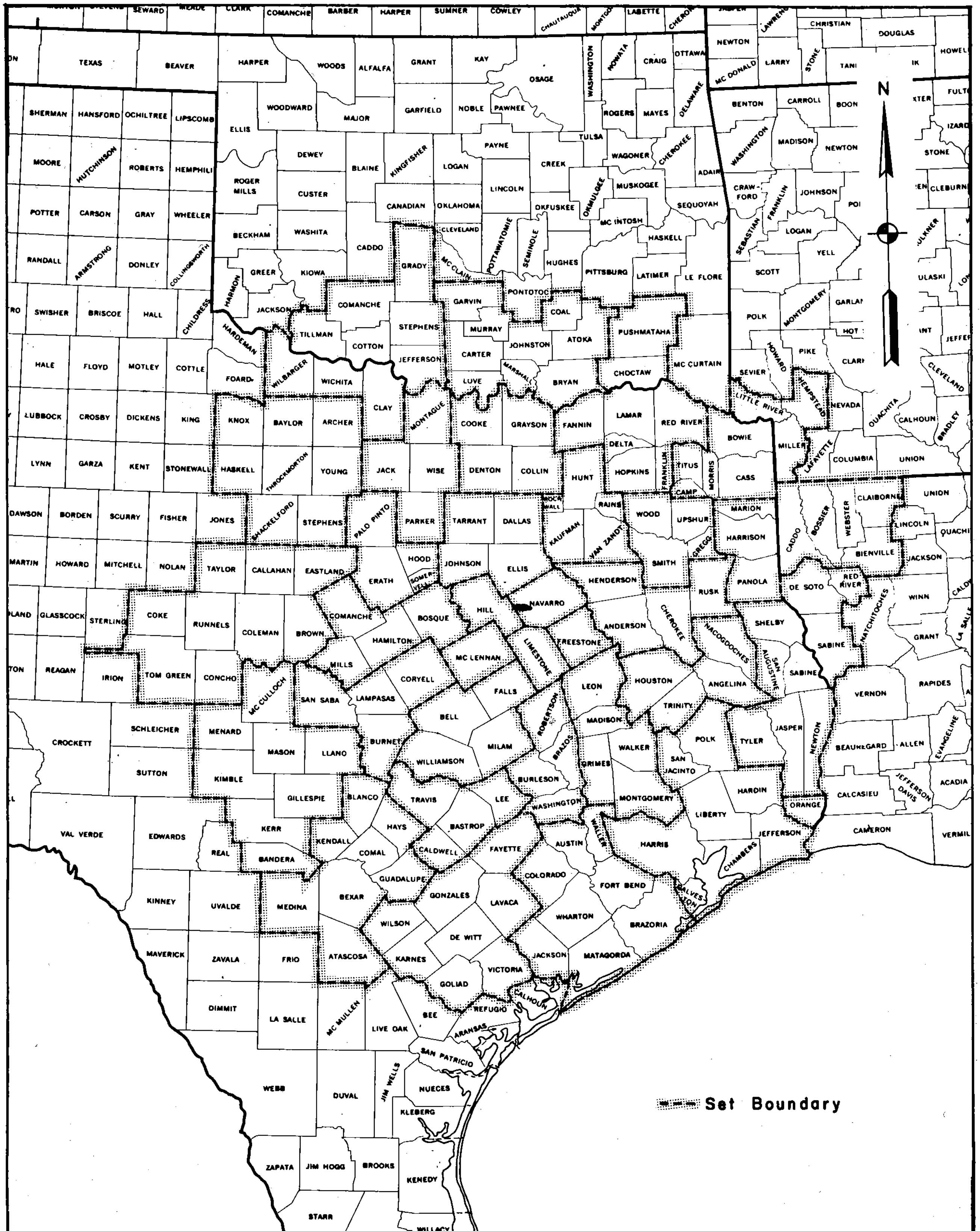


COUNTY SETS
LAVON RESERVOIR

FIGURE A-6



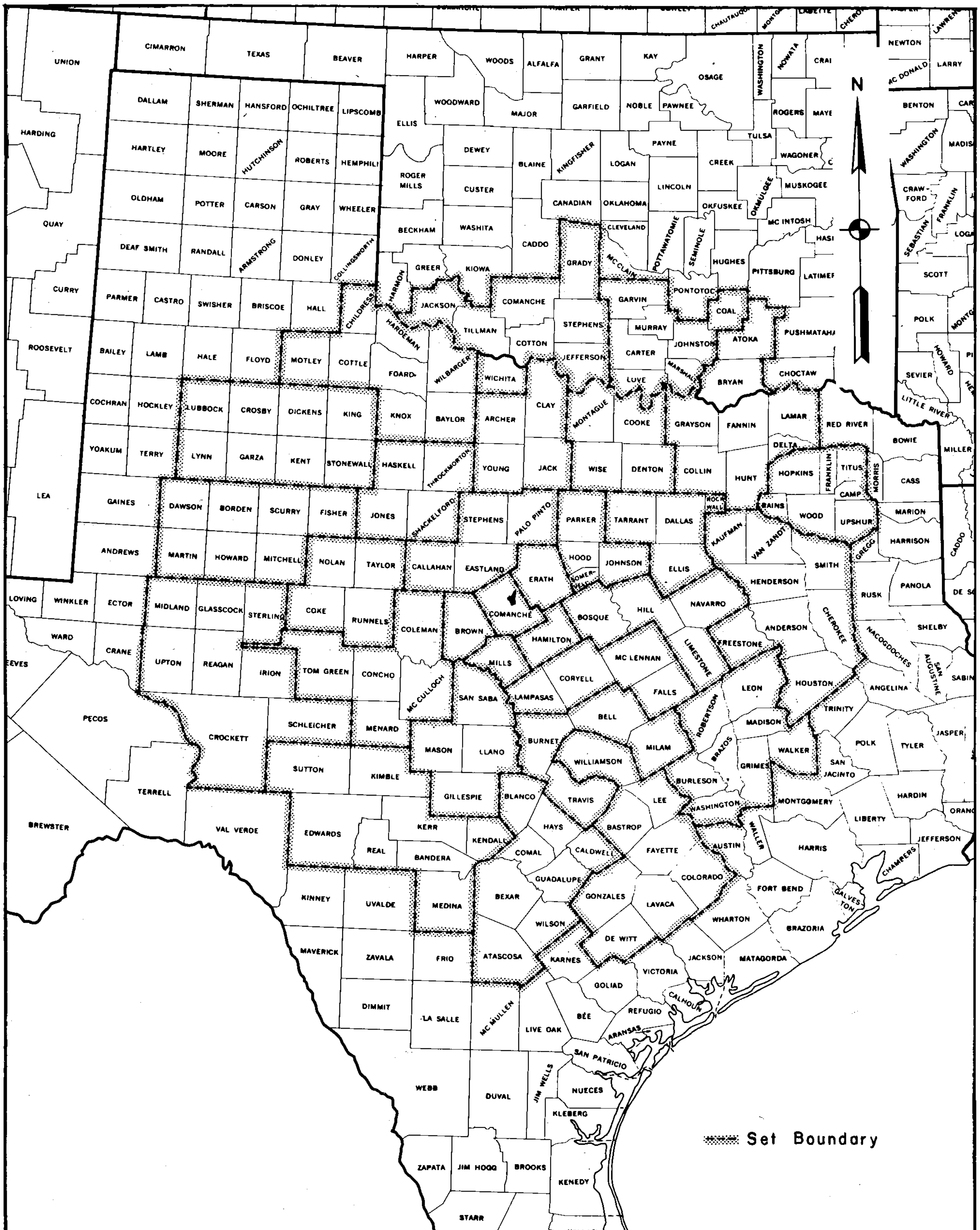
COUNTY SETS
GARZA-LITTLE ELM RESERVOIR
FIGURE A-7



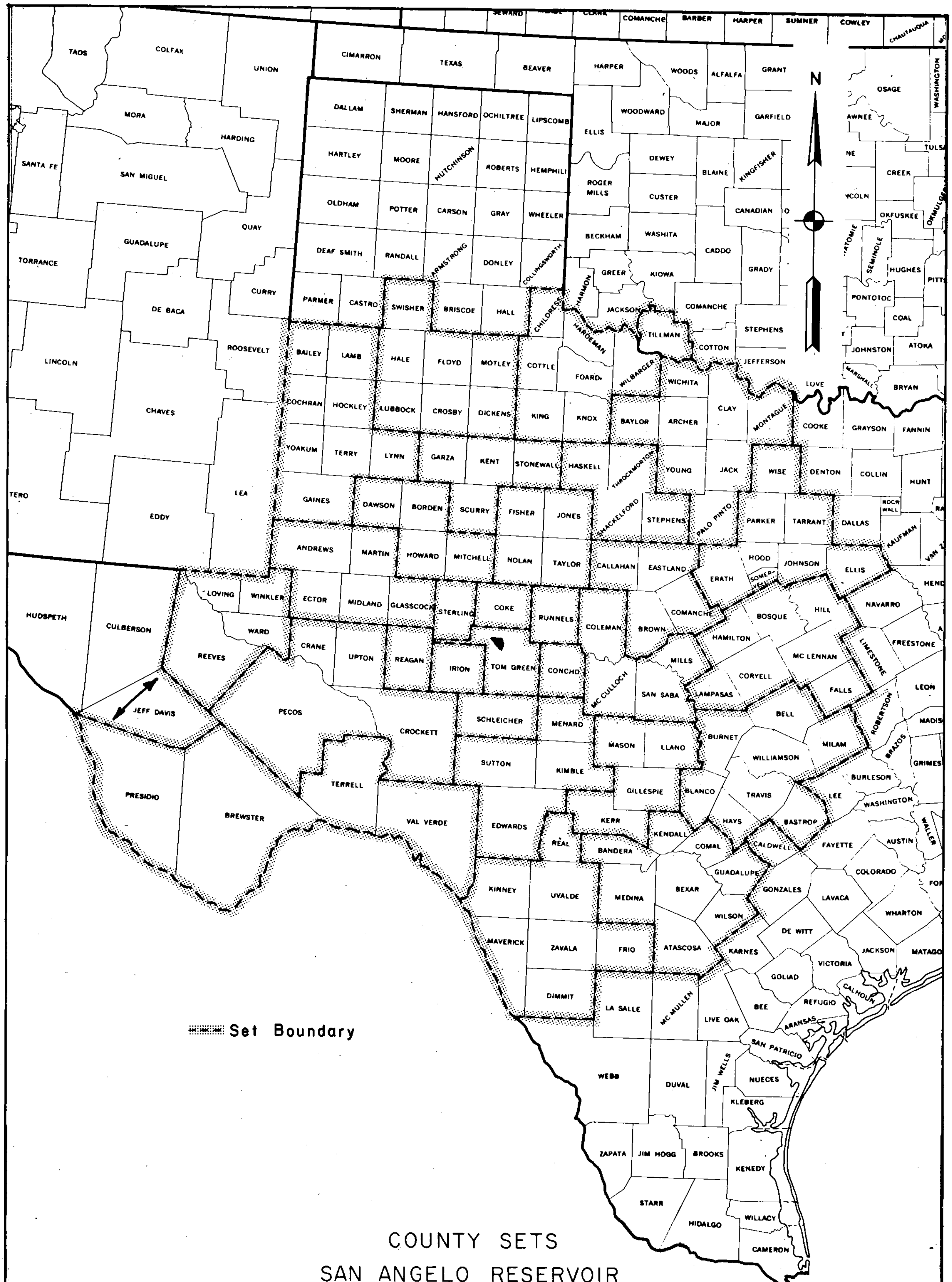
COUNTY SETS

NAVARRO MILLS RESERVOIR

FIGURE A-8

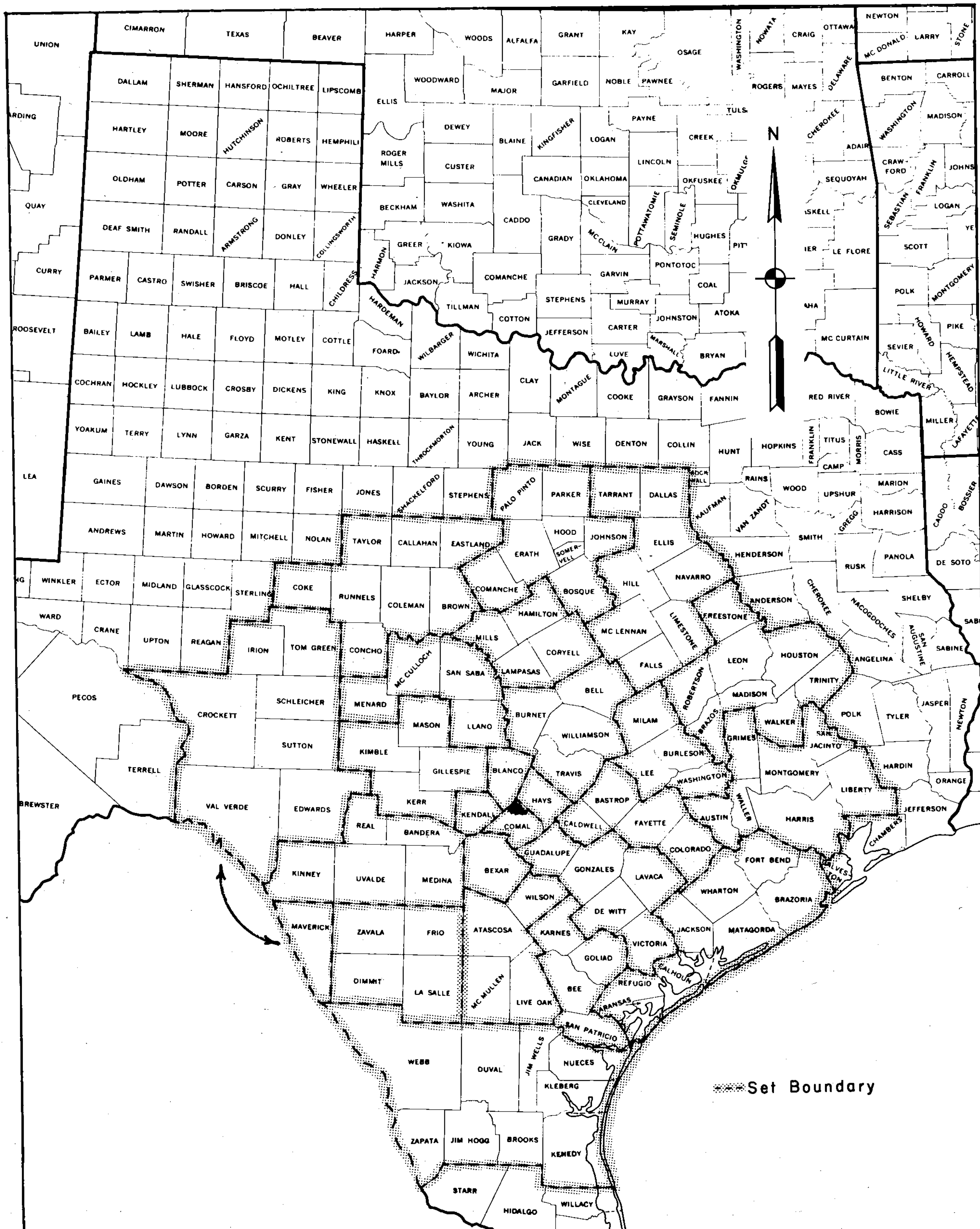


COUNTY SETS
PROCTOR RESERVOIR
FIGURE A-9



COUNTY SETS
SAN ANGELO RESERVOIR
FIGURE A-10

COUNTY SETS
WHITNEY RESERVOIR
FIGURE A-11



COUNTY SETS

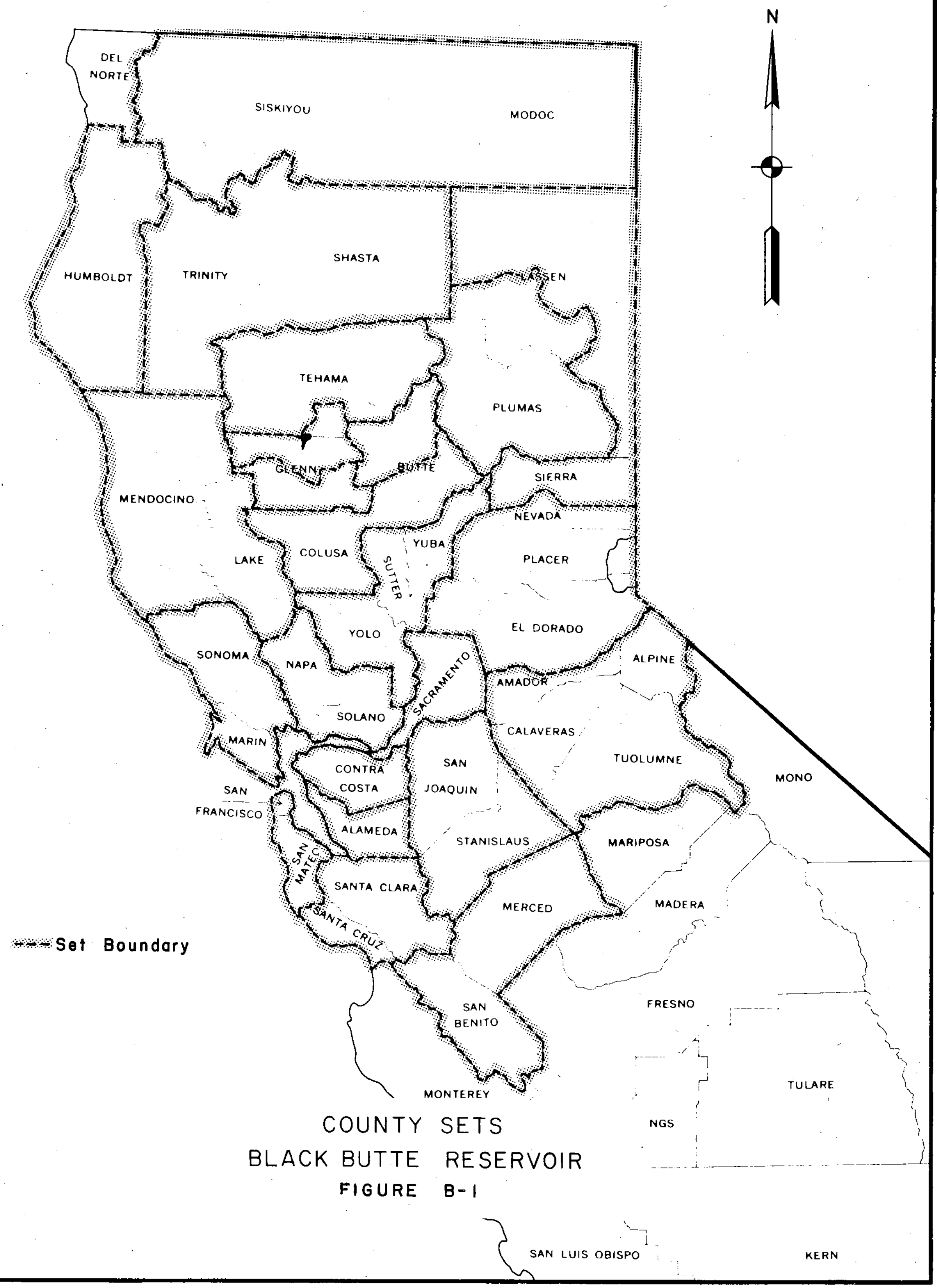
CANYON RESERVOIR

FIGURE A-12

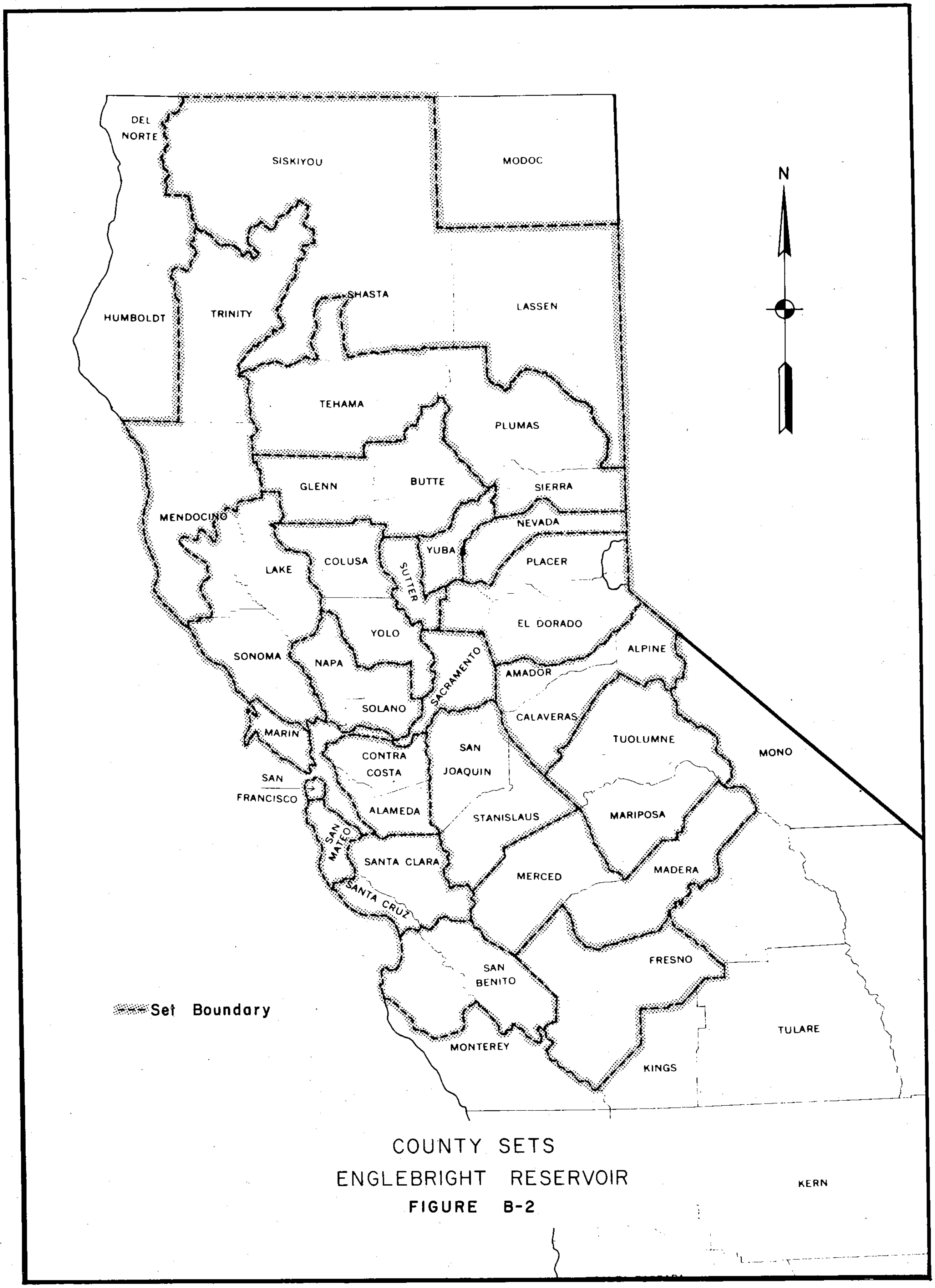
APPENDIX B

County Sets for Sacramento Region Reservoirs

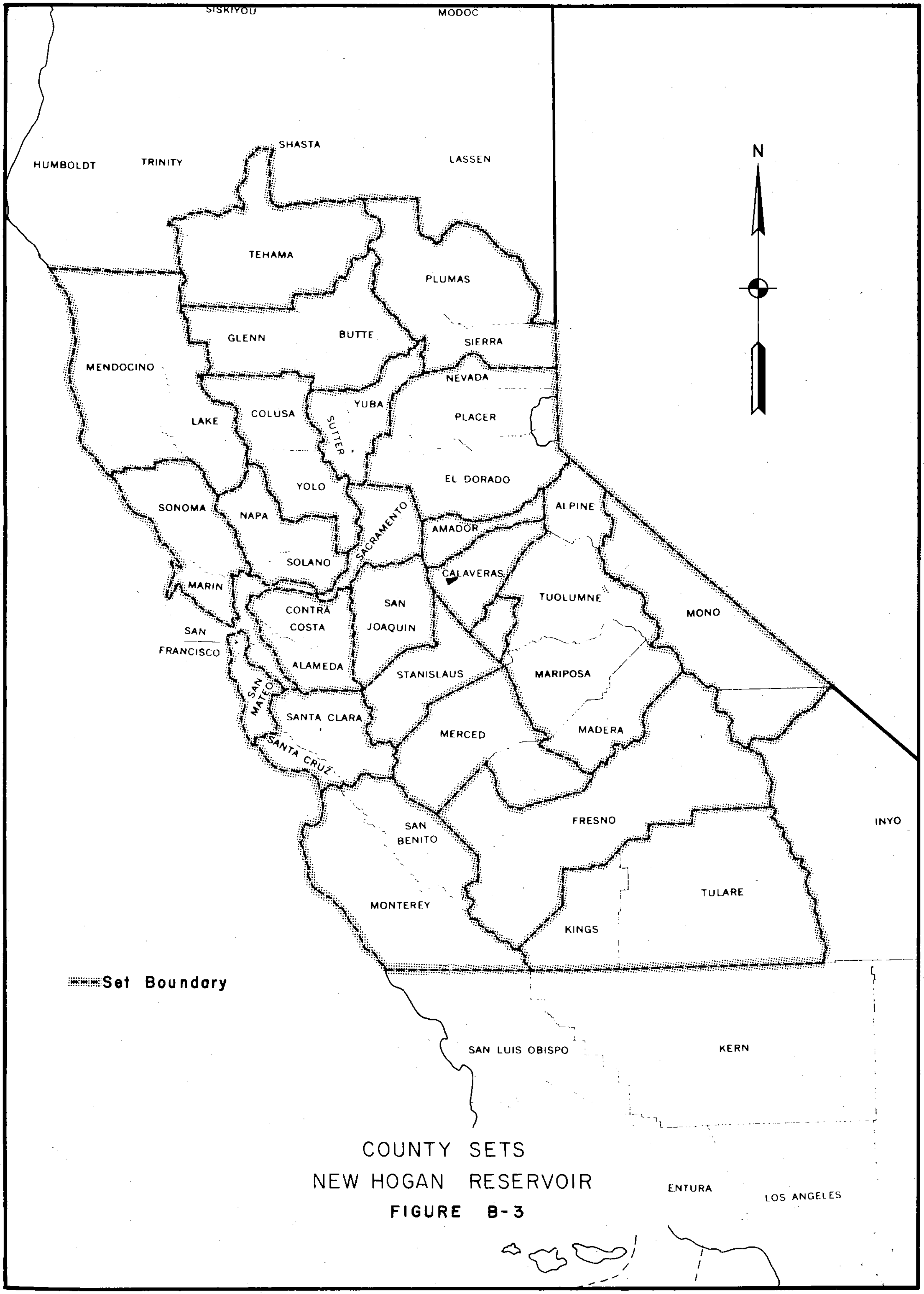
Figure	Reservoir - County Sets
B-1	Black Butte
B-2	Englebright
B-3	New Hogan
B-4	Pine Flat
B-5	Terminus
B-6	Success
B-7	Isabella



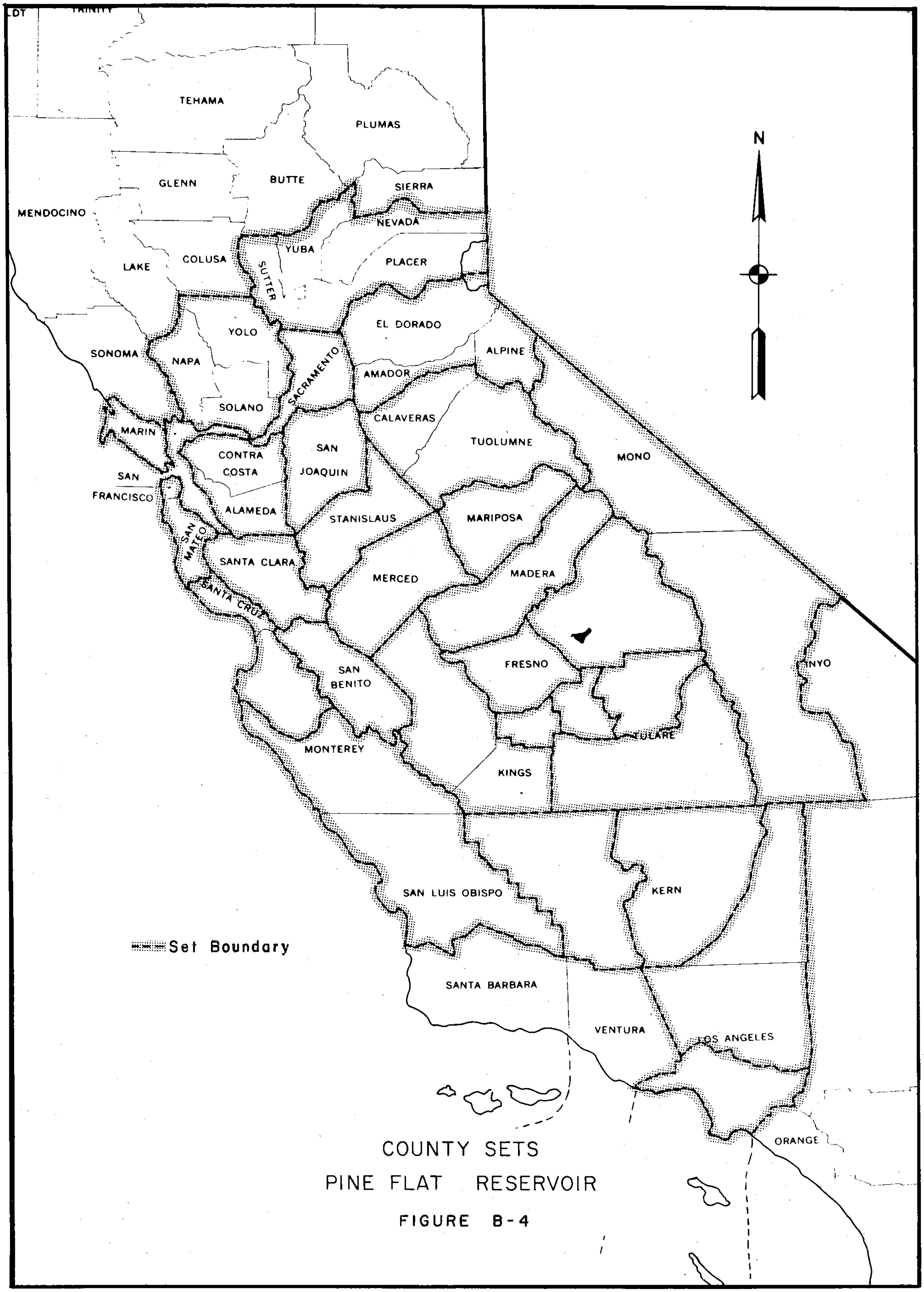
COUNTY SETS
BLACK BUTTE RESERVOIR
FIGURE B-1



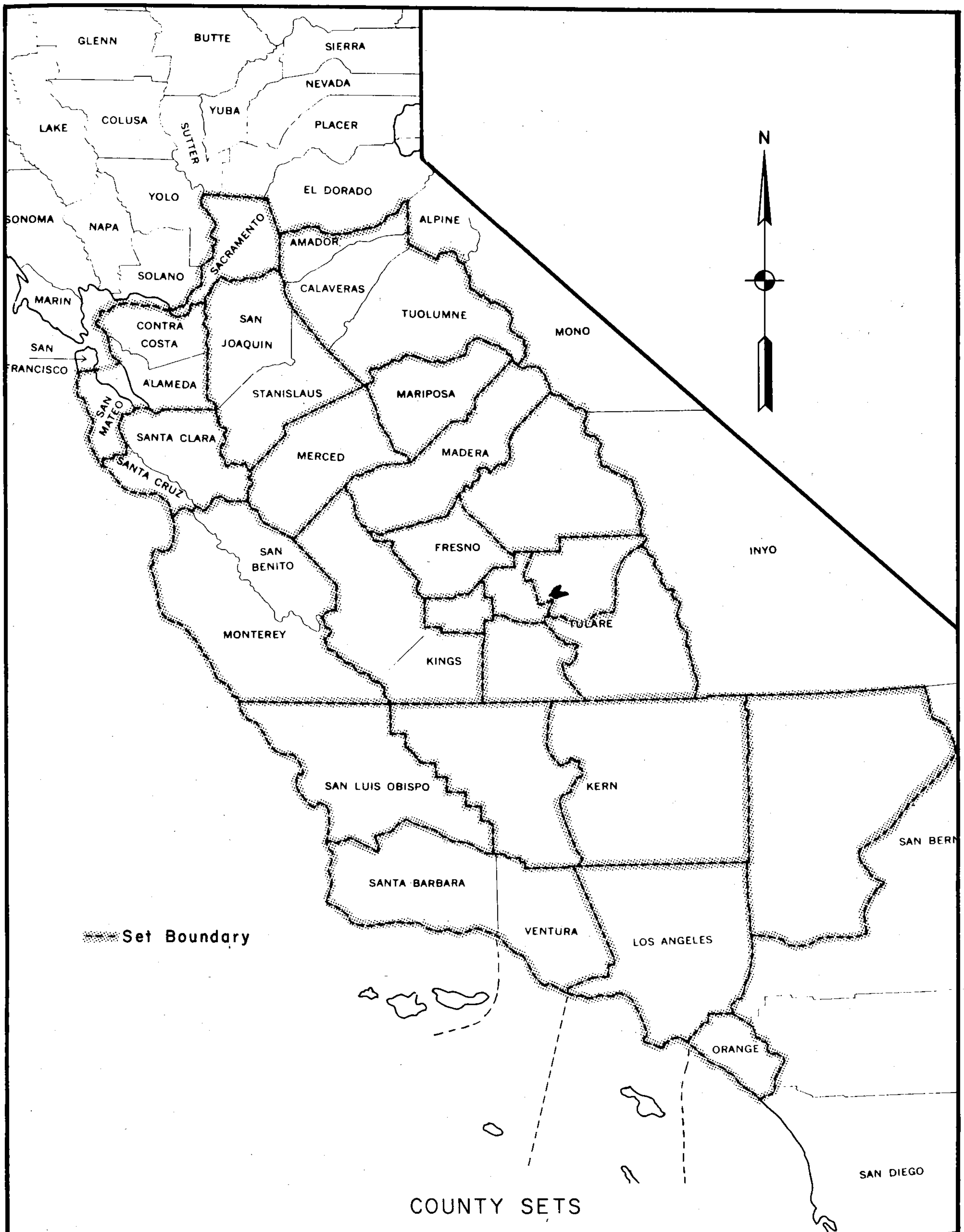
COUNTY SETS
ENGLEBRIGHT RESERVOIR
FIGURE B-2



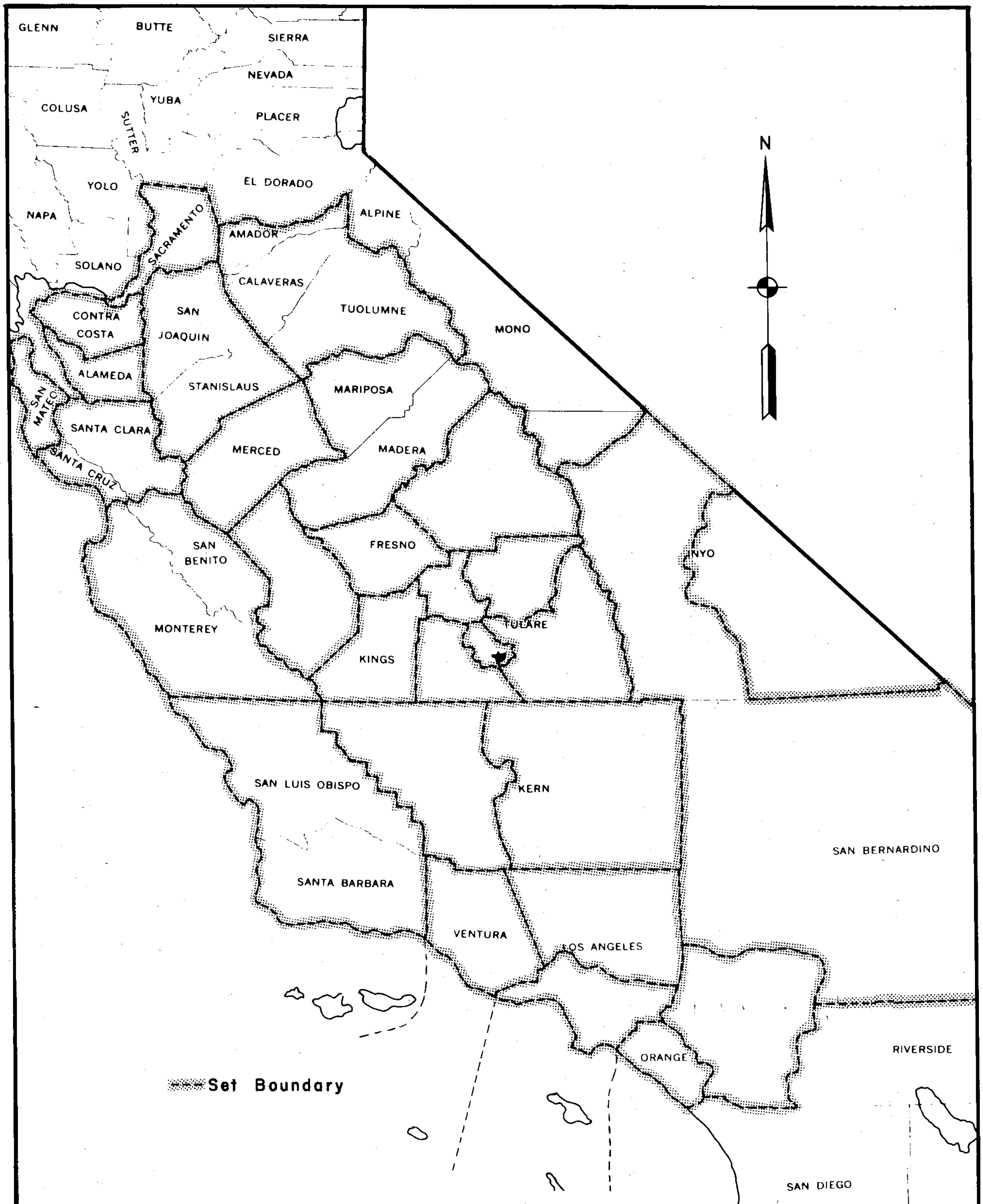
COUNTY SETS
NEW HOGAN RESERVOIR
FIGURE B-3



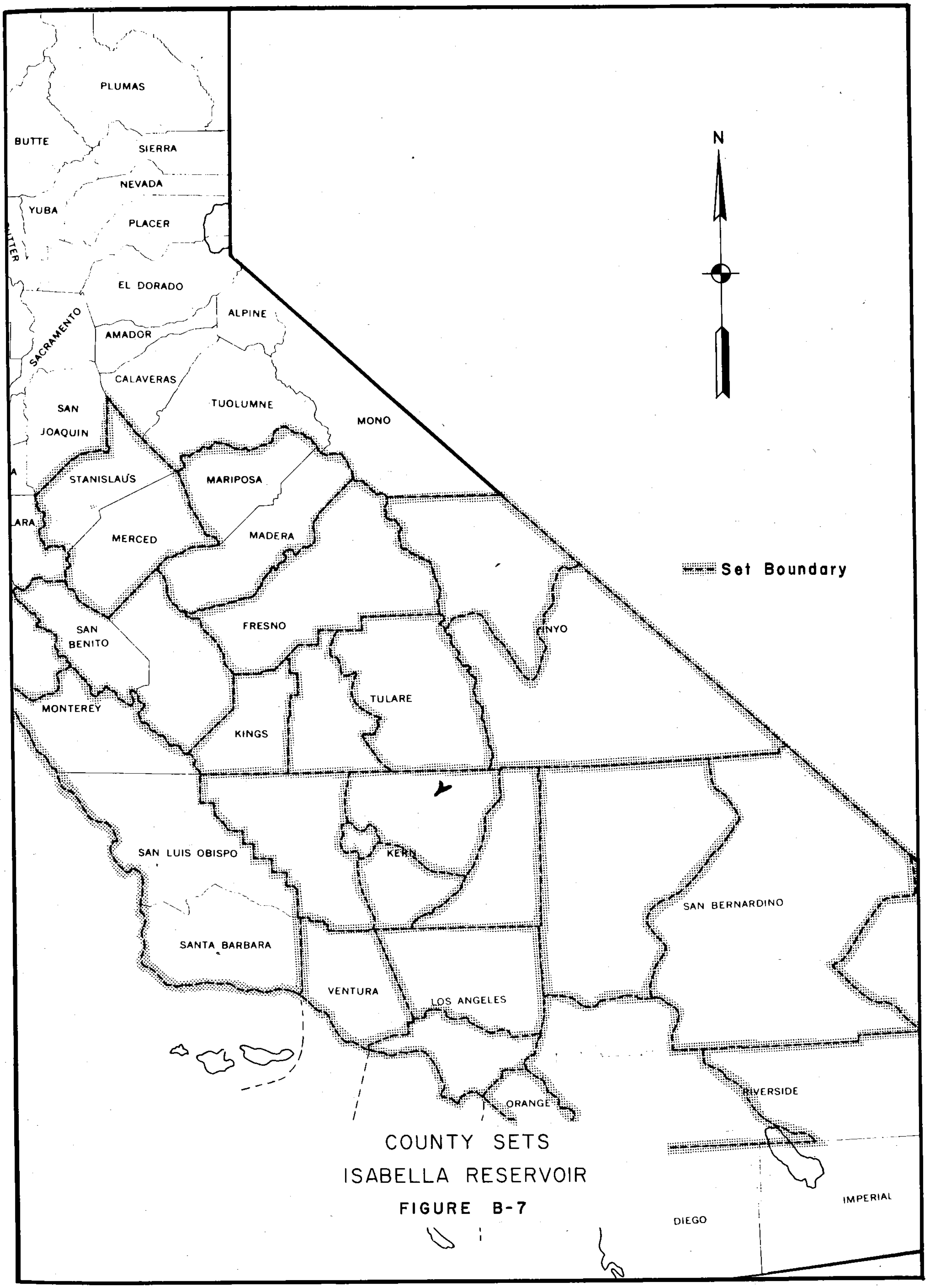
COUNTY SETS
PINE FLAT RESERVOIR
FIGURE B-4



COUNTY SETS
TERMINUS RESERVOIR
FIGURE B-5



COUNTY SETS
SUCCESS RESERVOIR
FIGURE B-6



COUNTY SETS
ISABELLA RESERVOIR
FIGURE B-7

APPENDIX C

An Example of Benefit Computations

APPENDIX C

The benefit calculations rely on the hypothesis that the disutility of distance is a function of time and money costs,

$$D = f(CT), \qquad (c-1)$$

and the assumptions that:

$$D = cD_c \qquad (c-2)$$

and

$$T = tD_t \qquad (c-3)$$

where c and t are the respective constant rates of money and time costs per mile; D_c is the distance associated with money costs; and D_t is the distance associated with time costs.

Since D_c and D_t are equal at a zero price (the initial observation points), it can be shown from (c-2) and (c-3) that:

$$CT = cD\ tD \qquad (c-4)$$

and

$$D = \left(\frac{CT}{ct}\right)^{1/2} \qquad (c-5)$$

The right side of equation (c-5) can then be substituted into the use estimator for D. Using the Sacramento estimator as an example yields:

$$Y_{ij} = -\ 4{,}285 + (P)_i \left(\frac{CT}{ct}\right)_{ij}^{-1/2} (-\ 2.66 + .0014W_j + 28Q_{ij}^{-2}) \qquad (c-6)$$

Substituting the values of C and T from (c-2) and (c-3) into (c-6) yields:

$$Y_{ij} = -\ 4{,}285 + (P)_i\ (D_cD_t)_{ij}^{-1/2} (-\ 2.66 + .0014W_j + 28Q_{ij}^{-2}) \qquad (c-7)$$

The points on the projects' demand curves are determined from (c-7) by holding D_t constant and incrementing D_c. For each increment of D_c a new use estimate is derived. The additional fee that these visitors would incur is assumed to be equal to the out-of-pocket travel costs associated with that increment. For the benefits reported in Table 6 a one mile increment was used associated with prices of 3.42 cents and 2.92 cents for the Fort Worth and Sacramento Districts, respectively. An example of the benefit calculations using the data from Englebright Reservoir and distance and price increments of 10 miles and 29.2 cents follows.

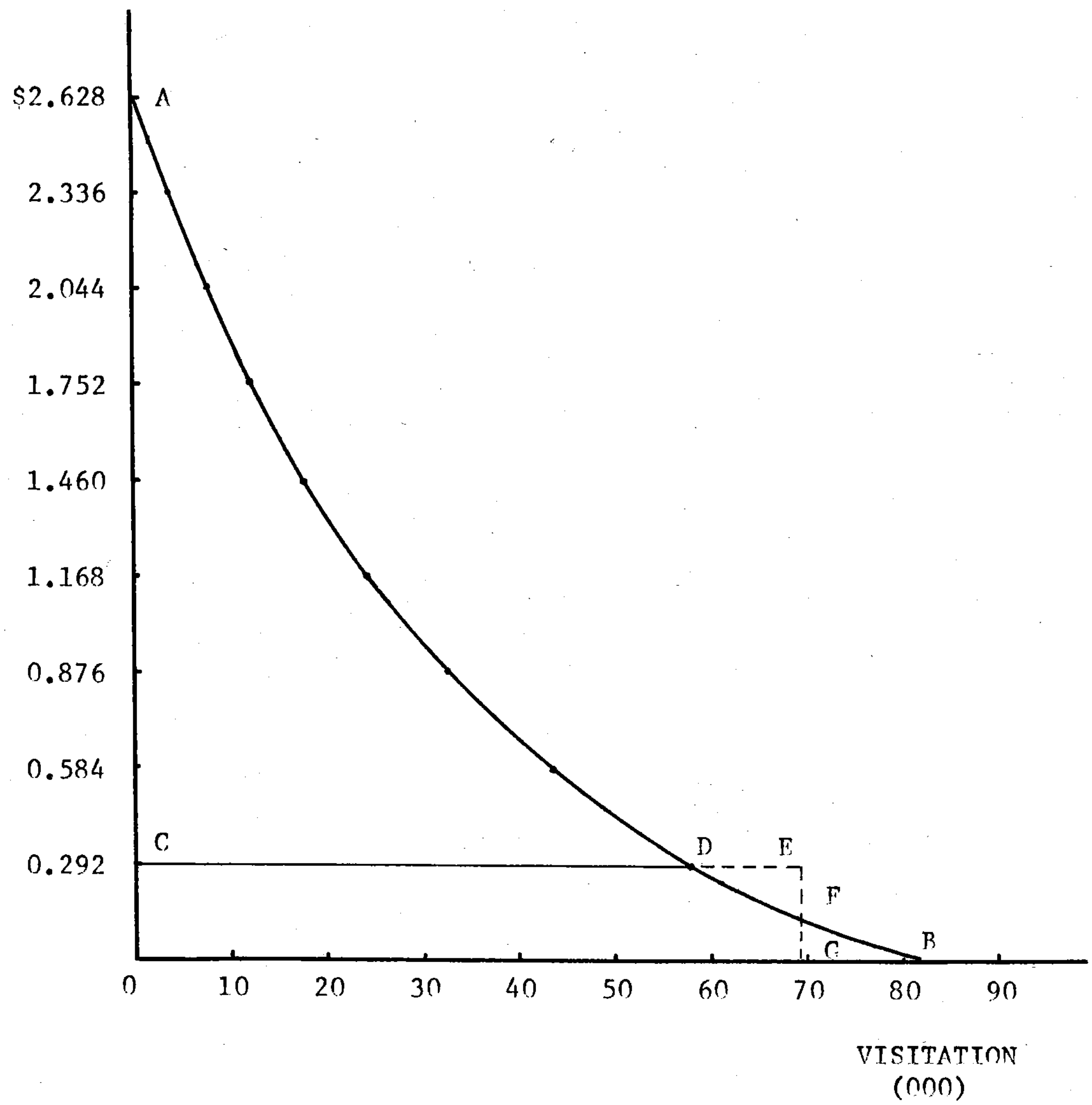
Using the Sacramento estimator and substituting the data for Englebright Reservoir yields an initial use estimate of 81,000 visitors. This is the amount of visitation that would be expected at a zero price. Increments of 10 miles are then added to D_c and the new expected visitation is measured (column (3) of Table C-1). These estimates are the amount of visitors that would be expected if various prices were charged (column (2) of Table C-1). The project's demand schedule is the curve fitted to the plot of the amounts of visitation expected at varying prices, Figure C-1. The curve AB represents the demand schedule for Englebright Reservoir and the area under this curve, OAB, is taken to be the measure of recreation benefits.

The area under the curve is computed by summing the areas associated with each increment in price. Thus in Figure C-1 OCDB is the area associated with the first increment in price. An approximation of OCDB is found by calculating the area of the rectangle OCEG, and assuming the area DEF is equal to GFB (the smaller the increment the less the significance of this assumption). The amount of use OG (69,500) is then equal to the average use between points B (81,000) and D (58,000); and the area OCEG ($20,294) is equal to OG multiplied by the price increment (always 29.2 cents in this example). Likewise the areas associated with each of the remaining price increments are calculated and then summed (as summarized in Table C-1) to find the total recreation benefits ($70,226).

TABLE C-1

(1) k	(2) Price	(3) Use	(4) Use_k + Use_{k-1}	(5) Average Use (4)/2.0	(6) Benefits (5) x 0.292
1	$0.000	81,000	-	-	-
2	0.292	58,000	139,000	69,500	$20,294
3	0.584	43,000	101,000	50,500	14,746
4	0.876	33,000	76,000	38,000	11,096
5	1.168	24,000	57,000	28,500	8,322
6	1.460	18,000	42,000	21,000	6,132
7	1.752	12,000	30,000	15,000	4,380
8	2.044	8,000	20,000	10,000	2,920
9	2.336	4,000	12,000	6,000	1,752
10	2.628	0	4,000	2,000	584
			TOTAL BENEFITS		$70,226

FIGURE C-1



$2.628
2.336
2.044
1.752
1.460
1.168
0.876
0.584
0.292
A
C
D
E
F
G
B
0
10
20
30
40
50
60
70
80
90
VISITATION
(000)

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: IWR Research Report 74-R1
2. GOVT ACCESSION NO.:
3. RECIPIENT'S CATALOG NUMBER:
4. TITLE (and Subtitle): Plan Formulation and Evaluation Studies - Recreation "Volume III of V - A Preliminary Analysis of Day Use Recreation and Benefit Estimation Models for Selected Reservoirs"
5. TYPE OF REPORT & PERIOD COVERED: Technical Report No. 3, June 1974
6. PERFORMING ORG. REPORT NUMBER:
7. AUTHOR(s): Richard E. Brown, William J. Hansen
8. CONTRACT OR GRANT NUMBER(s):
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Engineer District, Sacramento, 650 Capitol Mall, Sacramento, California 95814
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS:
11. CONTROLLING OFFICE NAME AND ADDRESS: DA, Office of the Chief of Engineers, Forrestal Building, Washington, D. C. 20314
12. REPORT DATE: June 1974
13. NUMBER OF PAGES: 69
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): US Army Engineer Institute for Water Resources, Kingman Building, Fort Belvoir, Virginia 22060
15. SECURITY CLASS. (of this report): Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE:

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Recreation Benefits; Recreation Day Use of Reservoirs; Estimating Recreation Demand

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report presents a methodology for estimating recreation use and recreation benefits at existing and proposed Corps of Engineers reservoirs. It is the outgrowth of recreation use studies instituted by the Office of the Chief of Engineers, Washington, D. C.

Multiple linear regression analysis is employed to develop two regional day use estimating models from recreation use survey data collected at

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) nineteen Corps reservoirs in the Fort Worth and Sacramento U. S. Army Engineer Districts. The estimators developed should be applicable for estimating day use at most existing or proposed Corps reservoirs within these regions.

The "travel-cost" model, which employs a "proxy for price" to derive demand schedules from the regional estimators, is presented. The model is illustrated by deriving demand schedules for the study reservoirs and estimating their recreation benefits.

The methodology presented is of considerably greater scope and intensity than other estimating procedures in current use and yields reasonable and useful results. Further improvements and refinements to the technique should result as additional recreation use data are collected and analyzed.